GEOLOGIC SURVEY OF THE EWING BANK, NORTHERN GULF OF MEXICO

A Thesis

by

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ABSTRACT

Located along the edge of the continental shelf in the northwestern Gulf of Mexico, the Ewing Bank is a significant geologic feature: yet, little information about the bank is generally available. This thesis represents a preliminary survey of the distribution and structure of the seafloor sediments that comprise the bank and the surrounding area. Two research vessels were utilized to accomplish the survey: the *RV Gyre* collected geologic cores and sub-bottom profiler lines courtesy of TDI-Brooks International and the *RV Falkor* collected multibeam echo sounder bathymetry courtesy of the Schmidt Ocean Institute. The bathymetry collected by the sub-bottom profiler and multibeam echo sounder data for this study is consistent with the coarser resolution data previously available. The pattern of seismic reflectors in the sub-bottom profiles indicated the orientation and type of faults as well as other structures. The geologic cores and sub-bottom profiler data helped to identify the different types and distributions of the sediments that made up this two terrace bank system. A core from the surface of the top terrace contained coarse carbonate sands while the seafloor surrounding this bank was comprised of firm clay sediment. The characteristics of surficial sediments on the second, deeper terrace were closer to those on the seafloor surrounding the bank than the top terrace of the Ewing Bank itself. This difference may reflect winnowing by the shelf edge currents interacting with the structure of the Ewing Bank together with the fact that the top terrace was subject to shallow water wave action and subaerial exposure during the lowstand of sea level associated with the last glactiation; while the surficial sediments of the second terrace were deposited since sea level rose after the end of the last glaciation. The features of the Ewing Bank compared well with those of the surrounding banks of the area. The results of this preliminary survey of the Ewing Bank contribute to the general understanding of the geologic features and biological habitat at the many banks in the north western Gulf of Mexico and the geologic processes that affect them.

DEDICATION

This thesis is dedicated to:

My parents, Dr. James Brooks and Lucinda Brooks, for their support and encouragement.

My wife, Megan Brooks, for her understanding and patience.

My mentor, Dr. William Bryant, for his wisdom, friendship, and inspiration.

ACKNOWLEDGEMENTS

I am appreciative of the opportunity that Dr. Bill Bryant has provided me to be involved in oceanography at Texas A&M University and the studying of the Ewing Bank. I would like to thank Dr. Niall Slowey and Dr. Thomas McDonald for their support and advice as part of my advisory committee. I also thank my fellow graduate student, Elda Ramirez, for sailing on the *RV Falkor* cruise and working with the crew of the ship to collect the multibeam echo sounder data. Thanks should also be presented to Dr. Troy Holcombe, Dr. James Brooks, and all others who have helped me along my journey.

I would like to thank all companies and agencies involved in this study that has taken place in the northern Gulf of Mexico: Texas A&M University, the Schmidt Ocean Institute, and TDI-Brooks International.

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1. INTRODUCTION

The northern Gulf of Mexico has many carbonate bank structures that are located on the shelf edge. These banks are known to host a variety of marine life and exhibit many geologic features. Because the Ewing Bank is one of the last unexplored banks of the northwestern Gulf of Mexico, a preliminary survey of the Ewing Bank provides a unique opportunity to improve our understanding of an important area that has not been well studied before.

The survey area is located at the edge of the Texas-Louisiana Continental Shelf (Figure 1). It covers approximately 4 x 8 nautical miles and is located at 28.10 °N and 91.03 °W. Water depths in this area range from 60 to 200 meters (Bright, 1979). Diaphus Bank and Bouma Bank as well as many others banks are present in the area.

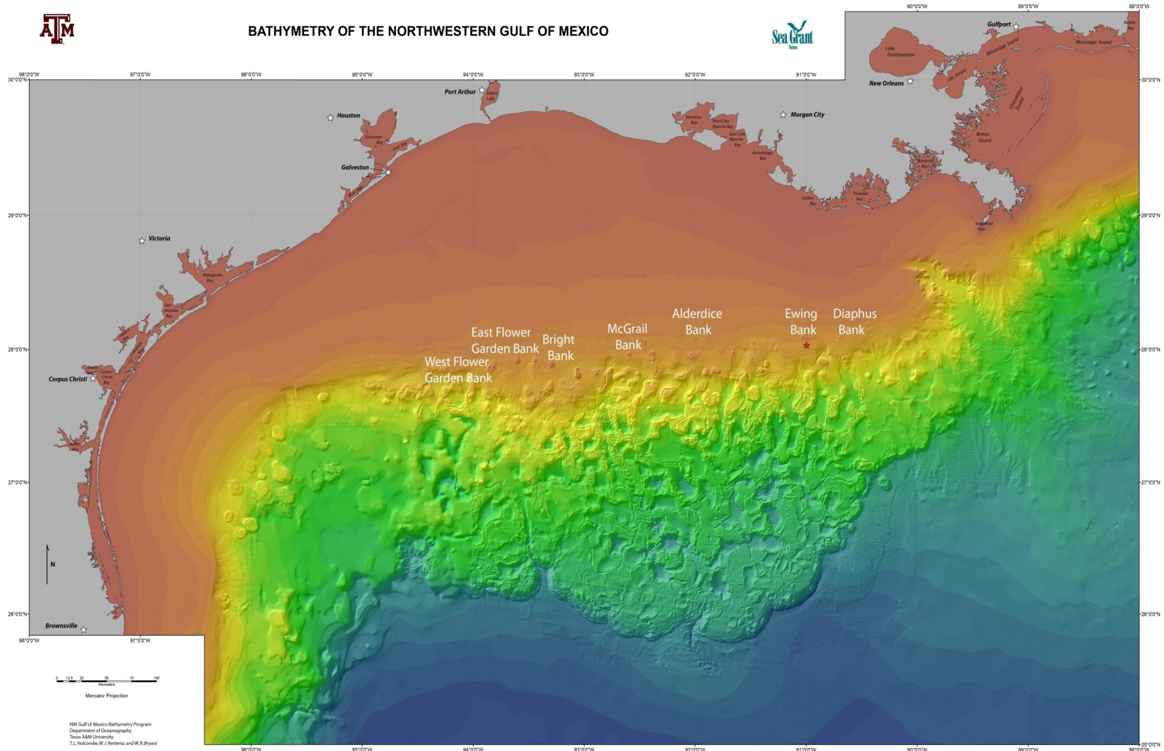


Figure 1: Bathymetric chart of the northwestern Gulf of Mexico Banks. Adapted from (Holcombe et al., 2013). The red star indicates the location of Ewing Bank.

Texas A&M University, with the encouragement of NOAA, developed a plan to survey the Ewing Bank in the Gulf of Mexico. This interest arose from the desire to gain basic knowledge about the geology of this bank and to help other scientists better understand its role as a biological habitat due to a high number of whale sharks that have been observed in the area (Hoffmayer, 2011). It is through the collection of sediment samples and sub-bottom profiler data from the seafloor, together with bathymetric mapping of the Ewing Bank, that facts can be established about its origin and the environment, that give it the features present at the bank today.

The specific objectives of the thesis research presented here were to conduct a preliminary survey of Ewing Bank and the surrounding seafloor, during which sediment core samples, sub-bottom profiles, and bathymetry data would be obtained, and then used to better understand the distribution and structure of the seafloor sediments that comprise the bank and the area that surrounds it. To accomplish these objectives, two research vessels were utilized to collect sub-bottom profiler images, geologic box cores, and multibeam bathymetry data. The *RV Gyre* was utilized on May 27 – 28, 2012, courtesy of TDI-Brooks International, was used to collect the sub-bottom profiler data and geologic cores. The *RV Falkor* was used on November 27-28, 2012, courtesy of the Schmidt Ocean Institute, to collect multibeam echo sounder data.

2. BACKGROUND

2.1 General Background

The Gulf of Mexico is located southeast of North America and borders the United States and Mexico. It is approximately 1,600 kilometers when measured east to west and covers an area of approximately 1.5 million square kilometers. It has a maximum depth of about 4000 meters and an average depth of 1,615 meters (Bryant et al., 1991).

According to Bryant et al. (1991), the Gulf of Mexico can be described as a circular structural basin filled with up to 15 kilometers of sedimentary rocks that range from Late Triassic to Holocene (230 Mya to present). Formation of the basin is generally thought to have originated during the Late Triassic when North America started to separate from Africa and South America and continued through the Jurassic and ended in the Cretaceous period, over 80 Mya. The deposition of sediments in the basin and their subsequent subsidence has continued as long as river flow has brought sediments into the basin from the continent (Rezek et al., 1983). The center of this basin is underlined by oceanic crust whereas the outer parts are continental crust (Bryant et al., 1991).

The continental shelf in the northwestern Gulf of Mexico ranges from the Rio Grande to the Mississippi Canyon, a distance of approximately 1,000 km (Slowey et al., 2008). It is considered to be gently sloping and goes down to approximately 120 to 200 meters of water depth before dropping onto the continental slope (Bryant et al., 1991).

The majority of banks in the northern Gulf of Mexico occur along this contact between the continental shelf and continental slope. Some reports have shown that there are over 200 shelf edge banks along the continental slope (Slowey et al., 2008).

The Ewing Bank is located in the Gulf of Mexico offshore of the border between Texas and Louisiana on the Texas-Louisiana shelf. It is located at 28.10 °N and 91.03 °W and is in roughly 200 meters of water. Historical NOAA bathymetric data suggests the bank has several terraces with the top terrace approximately 60 meters below the sea surface and the deepest terrace approximately 85 meters below the sea surface (Rezak et al., 1983). Rezak et al. (1983) noted that the Ewing Bank is thought to have a cover of generally soft sediments and is likely to have originated by salt diapirism.

2.2 Salt: Deposition and Movement

As the North American Plate began to separate from the South American and African plates during the Late Triassic and Jurassic time periods, Pacific Ocean waters began to fill the nascent Gulf of Mexico basin via central Mexico (Rezak et al., 1983; Bryant et al., 1991). The basin was intermittently covered by shallow seawater that evaporated and produced extensive salt deposits in the northern portion of the basin that are now know as the Louann Salt (Rezak et al., 1983). After this salt was deposited, it was subsequently covered by the normal deposition of other sediments. Once the Louann Salt was buried, it was able to move upward and laterally due to its plastic nature.

Post-depositional movement of sedimentary salt deposits can occur due to several driving mechanisms: buoyancy, differential loading, gravity spreading, thermal convection, and extension haleotectonics (Liu, 1993). In the northwestern Gulf of Mexico, two widely accepted causes for salt diapirism are differential loading of thick sediment on salt that has reached its buoyancy level (Liu, 1993), and simple buoyancy of the salt (Gardiner, 1986).

Many salt diapirs occur along the margin of the northwestern Gulf of Mexico due to the upward flow of Louann Salt (Rezak et al., 1983). Many of the banks that now are observed at the seafloor along edge of the continental shelf and upper continental slope are the surface expression of the movement of allochthonous salt within the seabed. The salt features have over time pushed up through over laying sediments and created dome features that rise above the seafloor. Thus, rising salt has played an important role in the formation of benthic habitat along shelf edge of the northwest Gulf of Mexico (Slowey et al., 2008).

2.3 Changes of Sea Level

It is well known that the during last glacial maximum (about 20,000 – 22,000 years ago) at the end of the Pleistocene epoch, sea level around the world was about 120 meters lower than it is at present (Davis, 2011). As sea level began to rise at the end of the last glaciation, benthic biological communities became established on many of the topographic-high features associated with salt diapirs, leading to the banks seen today.

The influx of glacial melt water and terrestrially-derived sediments into the Gulf of Mexico along with the rate of sea-level rise was highest from approximately 18,000 years ago until 6,000 years ago, when it began to slow down (Davis, 2011). It is likely that the Gulf of Mexico's sea level became stable around 3,500 years ago with only slight variations. The history of local sea-level in the northwestern Gulf of Mexico is also influenced by isostatic adjustments to the loading on the continental shelf by seawater (Rezak et al., 1983). Along the Mississippi-Alabama Shelf, just to the east of the present-day Mississippi River delta, Sager et al. (1991) found that most carbonate mounds are located in two isobaths parallel groups, between 120-105 meters and 90-74 meters, which could reflect periods of sea level rise or stand still during the last glacial maximum.

2.4 River Input

During the Cenozoic the Gulf of Mexico began to receive materials from the Laramide Orogeny to the North West (Rezak et al., 1983). Major sediment influx occurred from the Mississippi River and the Rio Grande River (Rezak et al., 1983). Sediment supply from the Mississippi River was so great that its fluvial processes dominated the marine processes, causing the entire shelf to prograde by approximately 400 kilometers from the edge of the Cretaceous shelf to the present shelf break; in other areas, the marine processes dominate and the smaller rivers do not have high enough sedimentation rates for the fluvial processes to dominate shelf development (Rezak et al., 1983). The Mississippi has put large quantities of sediment onto the shelf since the Pleistocene, which has caused major subsidence in the area (Rezak et al., 1983).

3. EQUIPMENT

3.1 Survey Vessel #1: *RV Gyre*

The *Research Vessel (RV) Gyre* was the ship that was used for this survey that collected the sub-bottom profiler data and geologic box cores. It is operated by TDI-Brooks International and has been used for various oceanographic studies in the Gulf of Mexico, Africa, Atlantic, Red Sea, and South China Sea. The vessel is certified by ABS and is current with all inspections and certifications (2012, TDI-Brooks). It has a length of 182 feet and beam of 36 feet. It will hold 23 scientists, with 14 marine crew, for approximately 35 days and has a maximum speed of 11 knots.

Figure 2: *RV Gyre*. (182ft) operated by TDI-Brooks International.

The *RV Gyre*, Figure 2, is equipped with a full range of oceanographic equipment, including an EdgeTech 3300-HM sub-bottom profiler imaging system. It can generate sub-bottom images at multiple frequency levels that are then recorded in SEG-Y for later processing and interpretation. A standard 0.5-meter box core was also used on the *RV Gyre* for the collection of geologic sediment cores. The use of this vessel to recover sub-bottom profiler images, and 0.5-meter box cores from the survey area is described in detail below.

3.2 Survey Vessel #2: *RV Falkor*

The survey vessel used for the multibeam echo Sounder data collection was the *Research Vessel (RV) Falkor* operated by Schmidt Ocean Institute. This vessel was built in 1981 in Germany and went through refitting in 2009 and in 2012 to be converted into an oceanographic research vessel. It is current with all inspections and certifications (Schmidt Ocean Institute, 2012). It has a length of 272 feet and beam of 39 feet. It will hold 20 scientists, 19 marine crew, for approximately 40 days and has a maximum speed of 12 knots.

Figure 3: *RV Falkor*. (272 ft) operated by Schmidt Ocean Institute.

The *RV Falkor*, Figure 3, is equipped with a high-resolution Kongsberg EM 710 multibeam echo sounder that was used for the second part of the Ewing Bank survey. It is a system that is suitable for shallow to intermediate water depths; the swath width can be up to 5.5 times the water depth.

It is worth noting that under typical conditions, the desired maximum ship speed when collecting multibeam echo sounder data with the *RV Falkor* is about 7 knots (Schmidt Ocean Institute, 2012). To maximize the area of the Ewing Bank that could be surveyed in the time available, the actual ship speed employed was about 12 knots, which resulted in slightly lower spatial resolution, but nevertheless quite useful data.

The use of the *RV Falkor* to collect multibeam echo sounder data and initial processing of the data onboard the ship, by the *RV Falkor* crew and Texas A&M graduate student E. Ramirez, is described in detail later on.

4. SUB-BOTTOM PROFILING

4.1 Methods – Sub-bottom Profiler

The sub-bottom profiler (SBP) used on the *RV Gyre* was an EdgeTech System 3300-HM sub-bottom profiler "chirp" imaging system. This is a hull-mounted system that uses a set of 16 transducers and operates on a frequency range from 500Hz to 12kHz. It generates wideband frequency modulated pulses that are transmitted through the water to the seafloor, where they reflect off of geologic features in the seabed. Cross-sectional images of the seabed are generated from the sound reflections and then displayed with various shades of color. The raw data received is recorded in SEG-Y format. This system has the ability to put more than one ping in the water column at a time and the ability to interpret which are transmitted and which are being received (TDI-Brooks, 2012).

4.2 Results – Sub-bottom Profiler

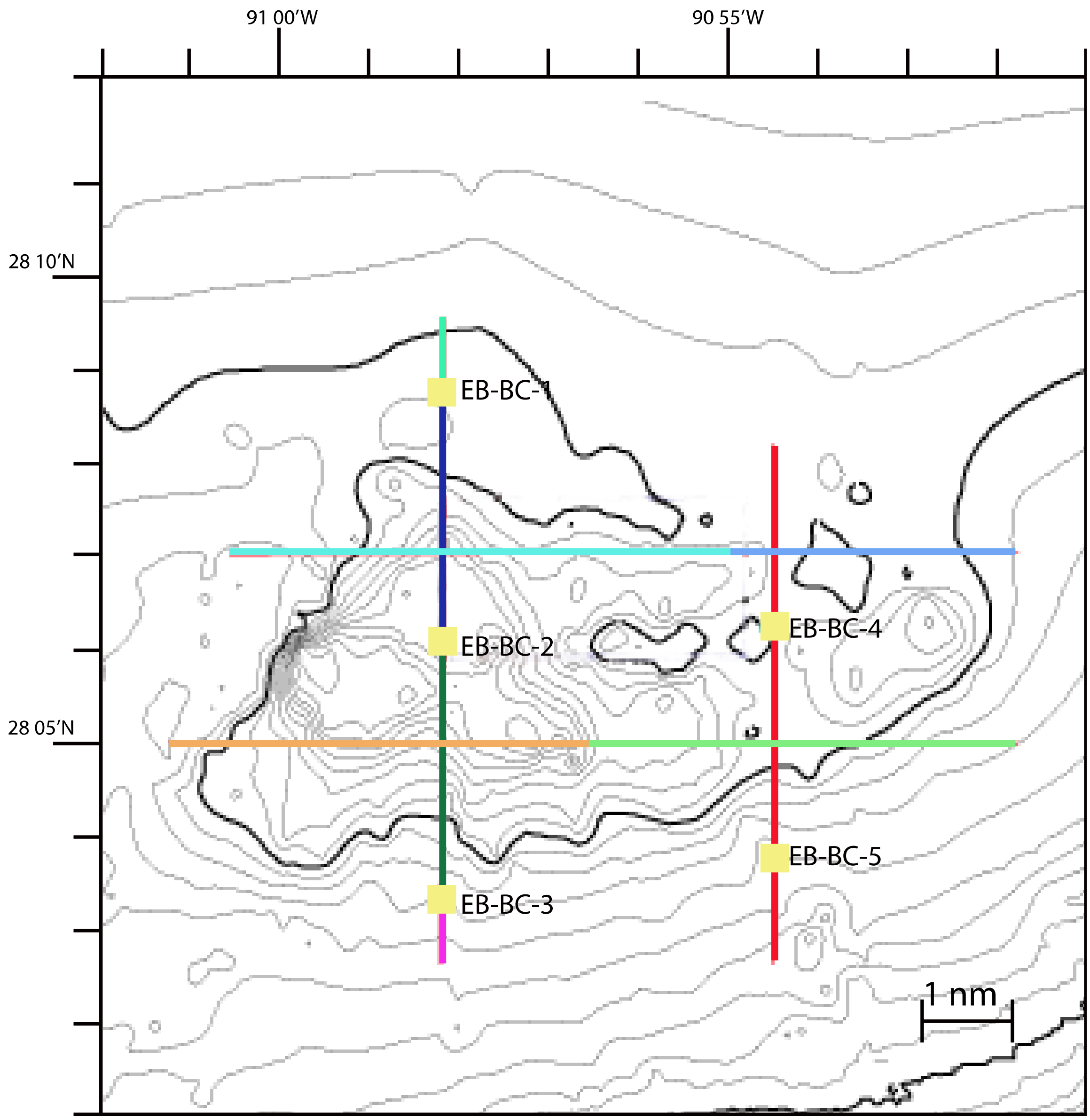


Figure 4: Sub Bottom Profiling Survey Lines and Sections on the Ewing Bank.

The Chirp lines for this survey area were broken up into sections as seen in Figure 4 above. The primary reason for this was sampling of box cores taken along the lines, however other reasons were technical difficulties and ship personnel scheduling. Figure 4 above shows how the 4 lines were broken up into 9 sections and shows exactly where the Chirp lines were taken in respect to the Ewing Bank. Each of the sub-bottom images will be described in the direction they were taken. Each line was collected in a Frequency Range of 2.5 to 4.0 kHz with a pulse length of 15 milliseconds. The typical penetration for this frequency and velocity would be 80 meters in clayey marine sediments and 6 meters in sandy marine sediments.

The W-E Chirp1 line was completed first and is represented by the color teal in Figure 4, and shown below in Figure 5 and Figure 6**.** As the line progresses from West to East there is an elevation change from the base of the mound to the top of the terrace. There is a step progress to this terrace: it first rises up from the seafloor and then levels its slope off. The top of this terrace is approximately 70 meters deep with the surrounding seafloor on the west side dropping down to 115 meters deep. The Chirp line then falls off the top terrace and moves across the middle terrace to the east until this chirp line ends. An important feature to note on this Chirp line is that the thickness of the seafloor reflection once it has increased in elevation is significantly darker and thicker than the seafloor reflection on the surrounding seafloor. The penetration is roughly 50 meters on the seafloor layers and decreases to approximately 10 meters on the top terrace. This decrease in penetration shows that there is an increase in hardness on the terrace layers that is not present on the seafloor. The hard seafloor reflection represents sand or coral that does not allow the same level of penetration as softer clays. It can also be seen that, the farthest east section of this line, the seafloor reflector associated with the middle terrace is not as dark and thick of a line as that at the middle of the line (top terrace) but is still darker than the seafloor reflector at the farthest left (west) portion of the section. There are tipped beds on the edges of the bank that indicate seafloor erosion processes and/or likely salt diapirism pushing the bank up. The reflectors at the edges of the bank appear to be laterally continuous, indicating similar sediment types (note the consistent thickness of the reflectors and presence of multiple reflectors with the same intensity). This image also shows onlapping of younger sediment on the edge of the bank that occurs over the tipped beds below, indicating that the bank was uplifted and then new sediment was deposited over the tipped beds. The onlapped younger sediment thins as it approaches the uplifted bank. Radial faulting can be seen on the top terrace, Figure 6, which is due to the uplift of the bank and the subsequent faulting as it expanded. This same uplift also produced folding in some of the layers that were uplifted.

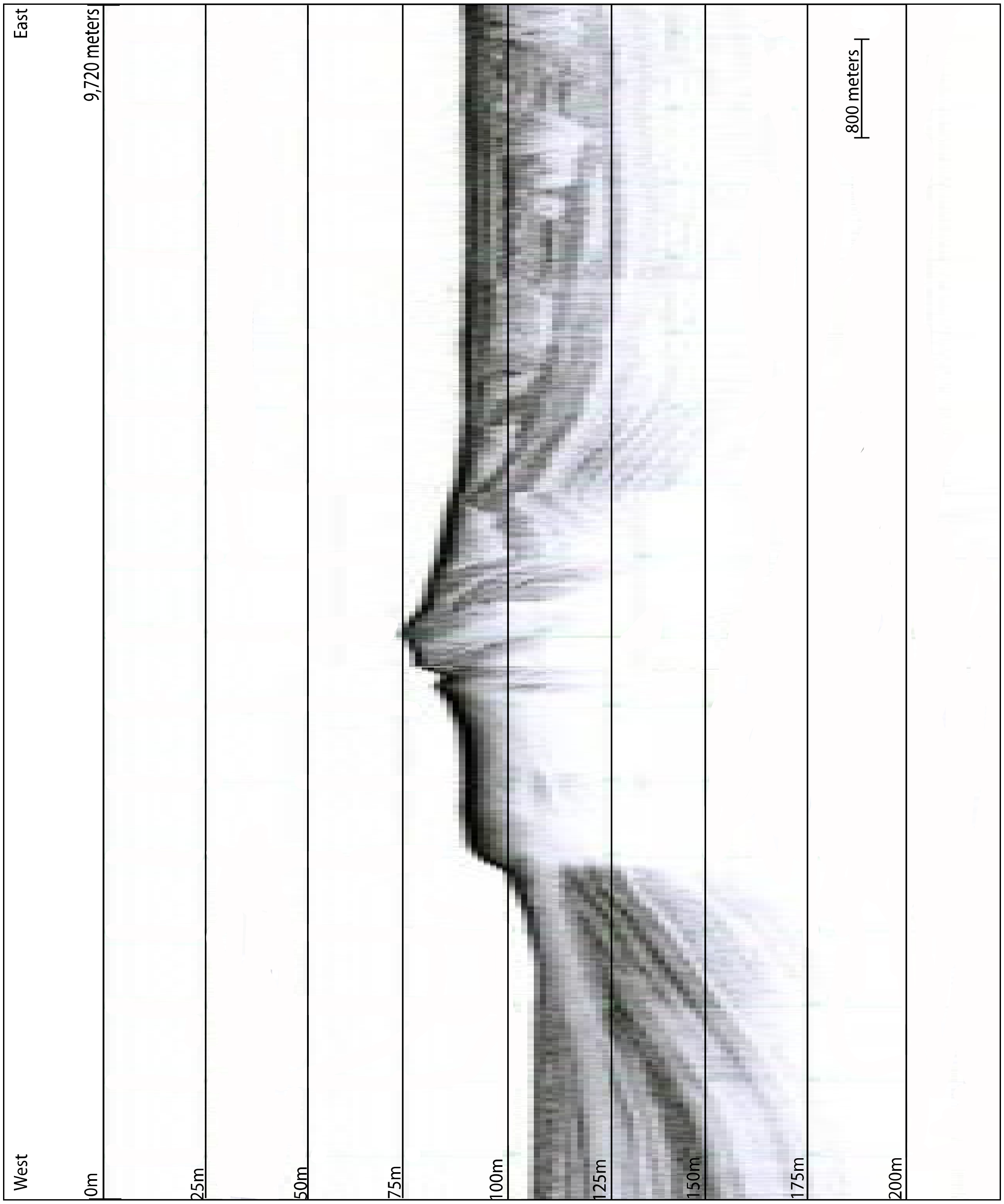


Figure 5: West to East Chirp1-a. Which is 9,270 meters in horizontal extent. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from two-way travel time presuming the sound velocity of 1500 m/sec.

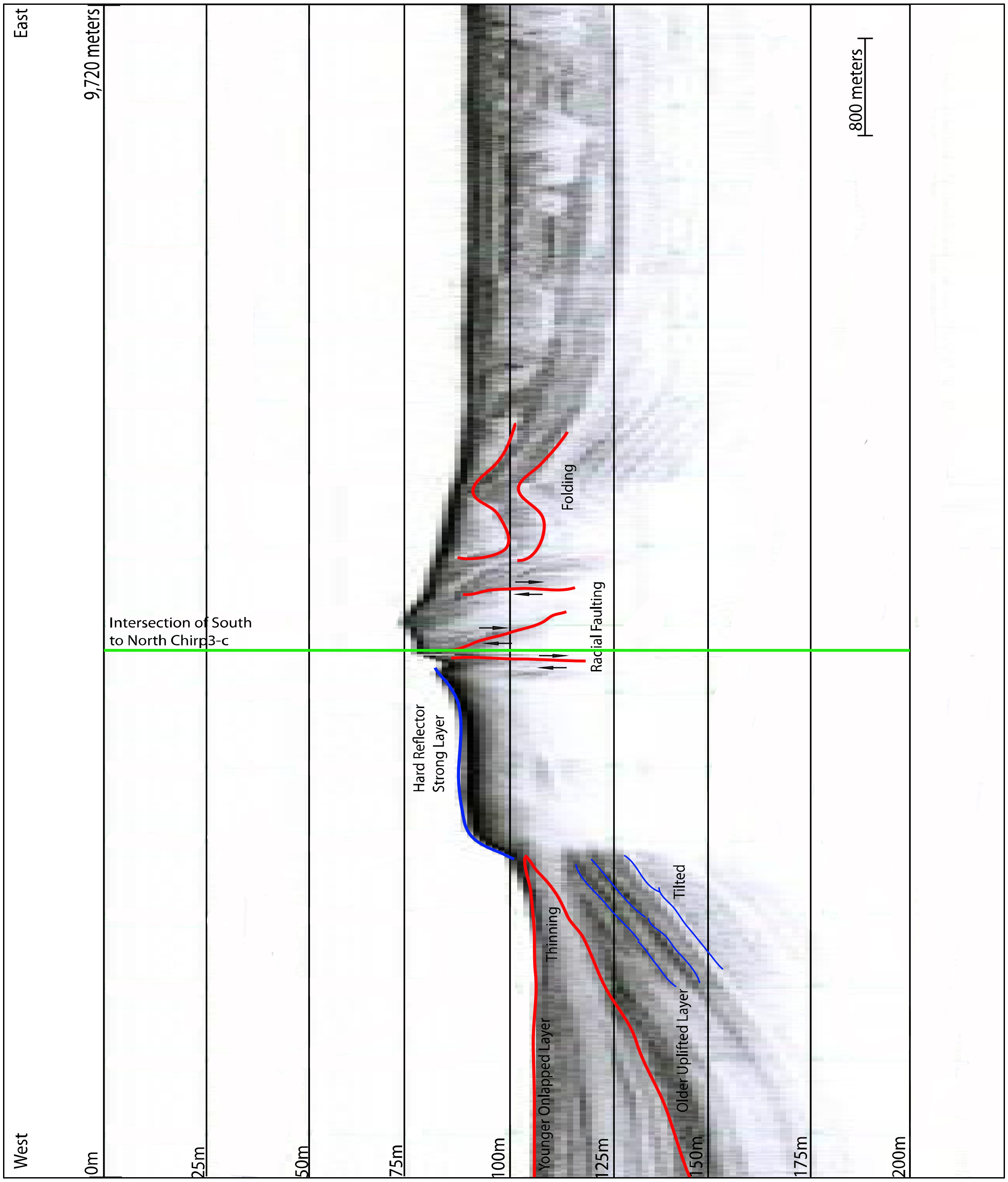


Figure 6: West to East Chirp1-a Interpreted. Which is 9,270 meters in horizontal extent. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from two-way travel time presuming the sound velocity of 1500 m/sec.

The rest of W-E Chirp1 line can be seen below in Figure 7 and Figure 8, and its location is represented in Figure 4 by the dark blue line. This line follows the same path as the first part of the Chirp1 line from West to East and runs out to the eastern boundary of the Bank. It can be seen that the thickness of the line is less intense and that it is lighter on the middle terrace than the top terrace. As it progresses to the East, it becomes thinner and lighter as it progresses up the eastern top terrace where penetration decreases to approximately 10 meters. The eastern top terrace has a hard reflector which indicates sand or coral. The elevation is also seen to decrease from West to East as the path comes off of the middle terrace and moves toward the outer portion of the eastern bank. With the exception of a slight increase in elevation near the end of the line, there is a small increase in elevation before dropping off to surrounding seafloor. The beds on the eastern edge of the bank are tipped significantly, indicating that this portion of the bank has been uplifted, likely due to salt diapirism. The center of this image, the area between the two top terraces, can be seen to be collapsed or depressed. The thickness of the reflector here is not as great as on top of the terraces and more layers are present due to greater penetration of approximately 50 meters. The reflector patterns suggest the collapse appears to be filled with softer, younger sediment that thins toward the west. Folding and radial faulting can also be seen in association with this collapse feature, Figure 8. The radial faulting is a result of the uplifted bank expanding.

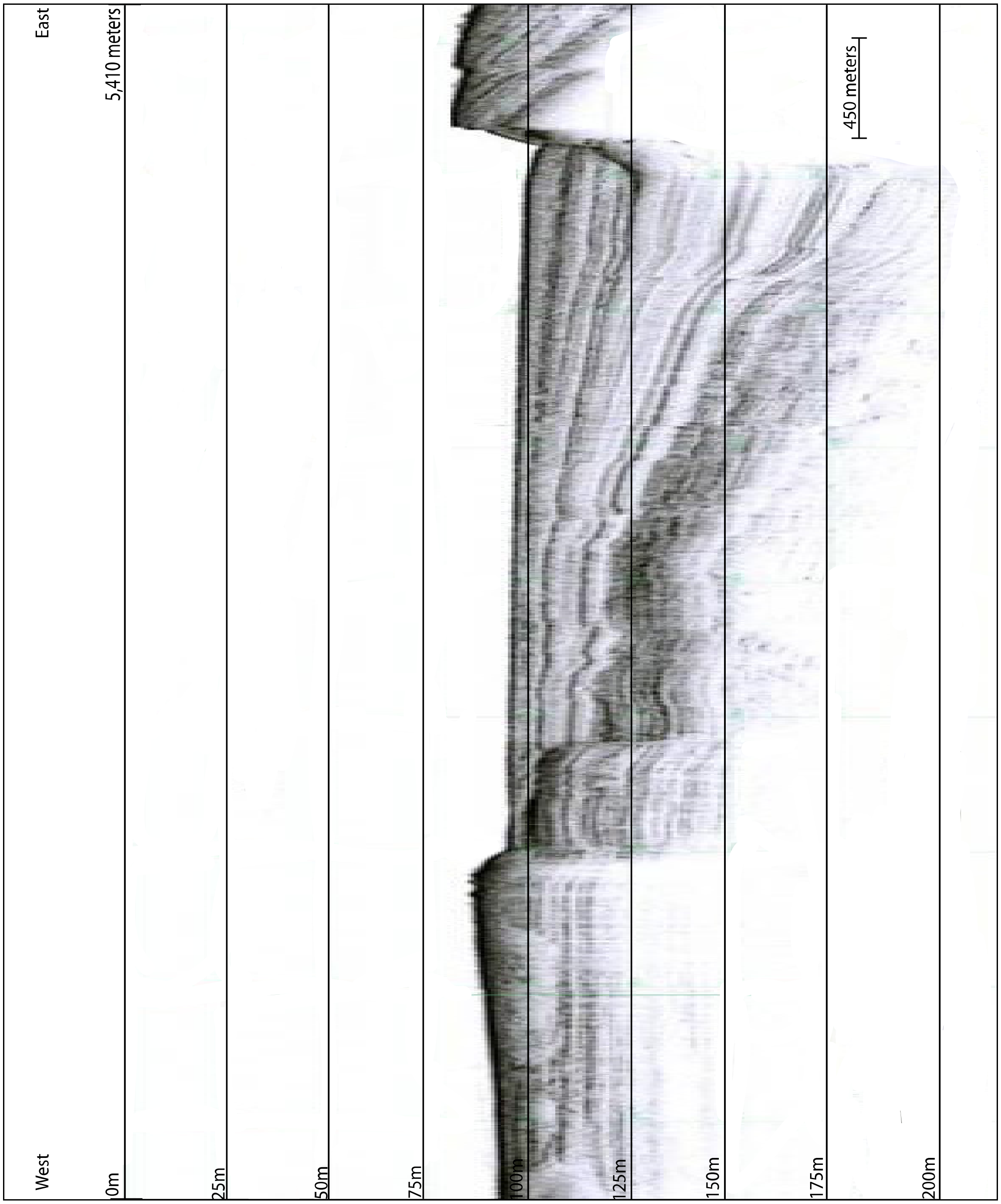


Figure 7: West to East Chirp1-b. Which is 5,410 meters in horizontal extent and the last section of Chirp1. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from two-way travel time presuming the sound velocity of 1500 m/sec.

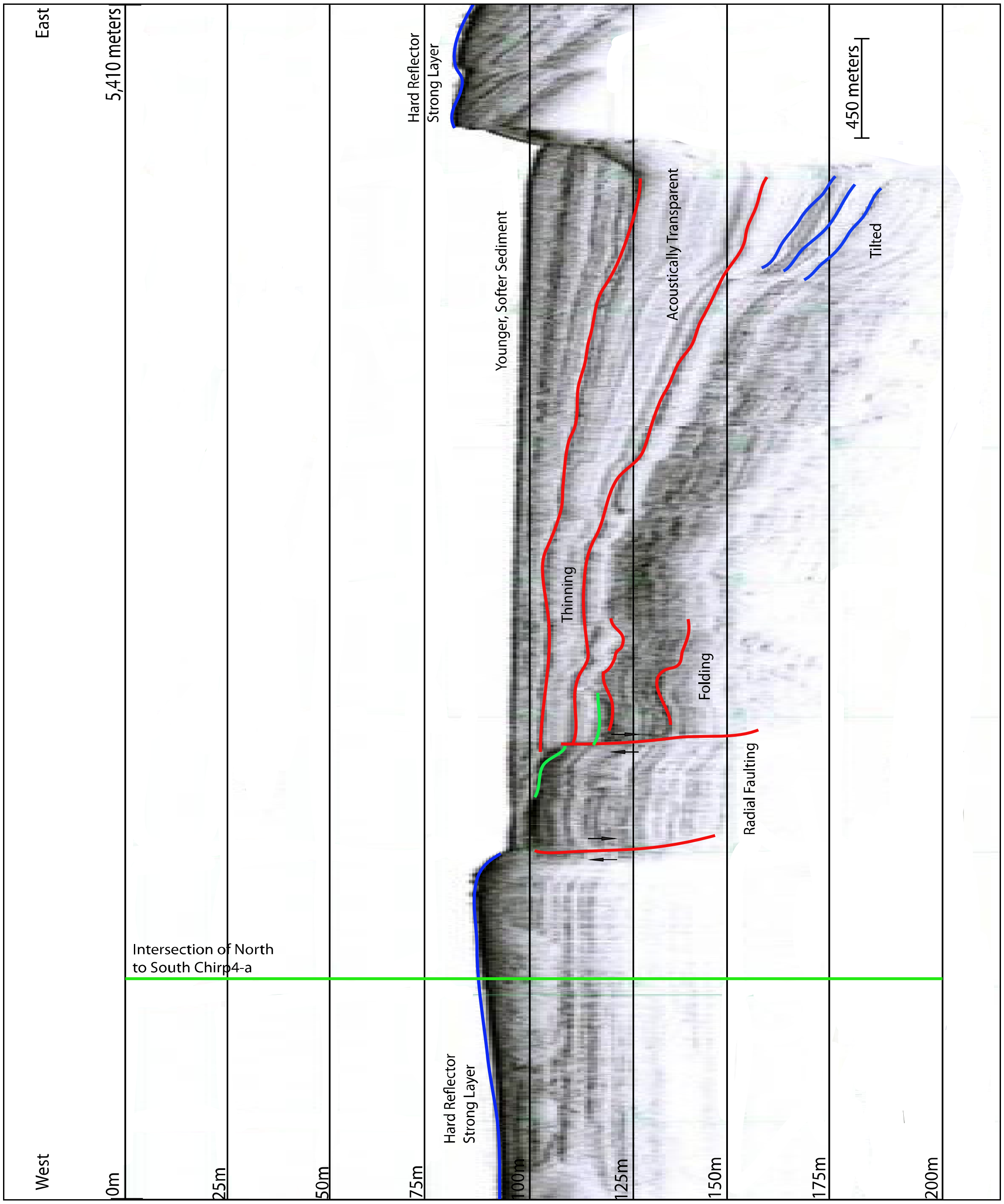


Figure 8: West to East Chirp1-b Interpreted. Which is 5,410 meters in horizontal extent and the last section of Chirp1. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from two-way travel time presuming the sound velocity of 1500 m/sec.

The East to West Chirp2 line is represented below in Figure 9 and Figure 10, and its location is indicated by the light green line in Figure 4. This line is very similar to the first West to East Chirp1 line but is taken farther south on the bank and in the opposite direction. The line crossed the highest elevation top terrace and showing a greater elevation change from the surrounding seafloor to the top of the bank. As shown below, the bank's elevation changes from East to West and as the seafloor becomes shallower, the seafloor reflection is thicker and darker. The pattern of seismic reflectors indicates that at the start of this line, the younger sediments lap onto the edge of the bank and thin up dip. Two sequences of reflectors exist, with older tipped beds occurring beneath the younger sediments. Penetration of the acoustic pulse on this outer edge of the bank is approximately 40 meters. The pattern of reflectors there indicate again that the bank has been uplifted causing these beds to be tipped and/or eroded by currents going on around the outside of the bank. The bank's elevation increases toward the west. The intensity of the seafloor reflection increases at the top of the terrace and acoustic penetration decreases to approximately 10 meters. Reflectors at the top of the terrace are tipped as well due to uplift. The amount of reflectors decreases, which would be consistent with increased sediment strength. A down dropped section occurs between the two terraces due to radial faulting (see Figure 10). At the western end of the Chirp line, a terrace with a strong seafloor reflection occurs with some folding beneath it. The folding is presumably due to the uplift of the bank.

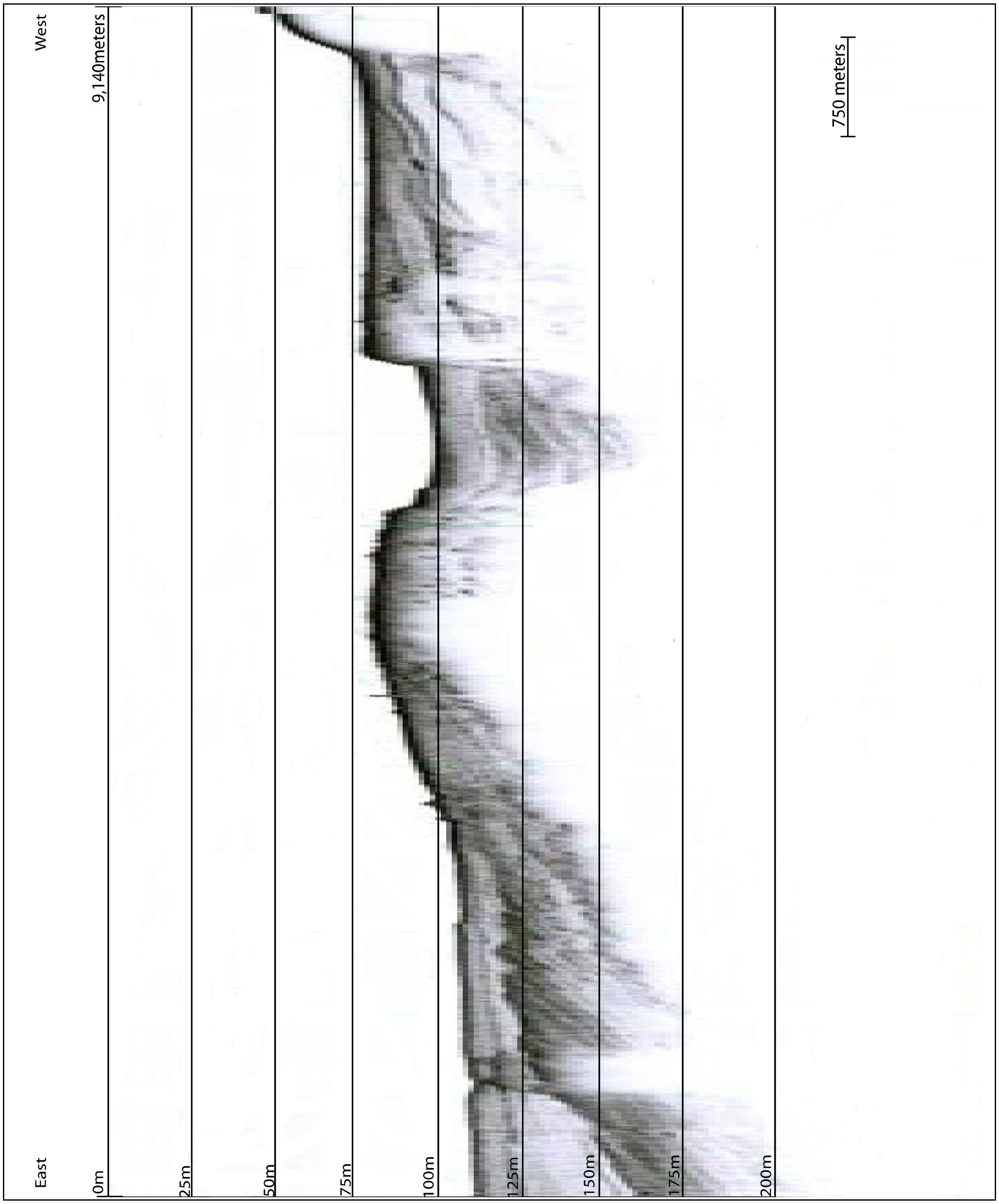


Figure 9: East to West Chirp2-a. Which is 9,140 meters in horizontal extent. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from two-way travel time presuming the sound velocity of 1500 m/sec.

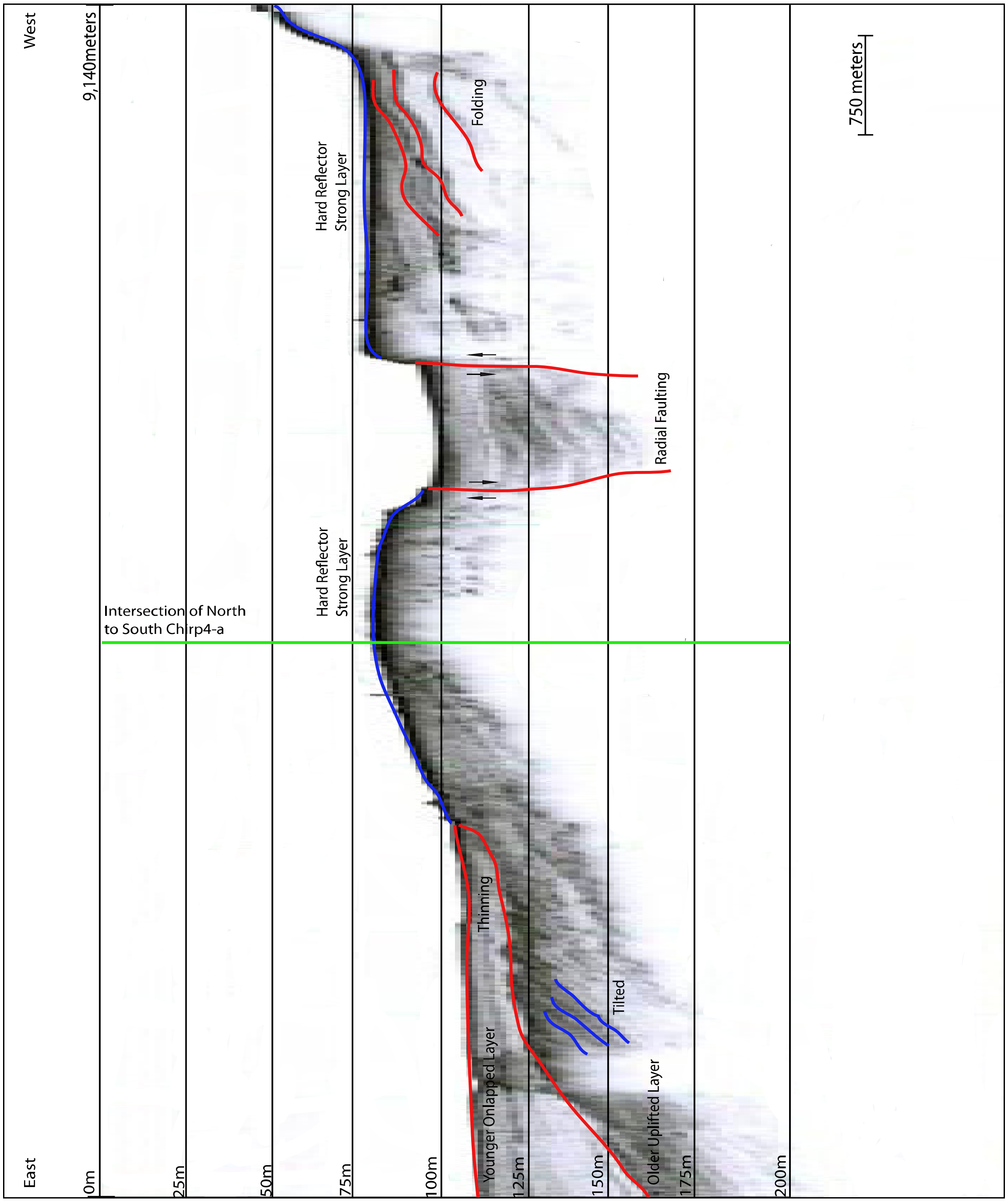


Figure 10: East to West Chirp2-a Interpreted. Which is 9,140 meters in horizontal extent. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from two-way travel time presuming the sound velocity of 1500 m/sec.

The rest of E-W Chirp2 line can be seen below in Figure 11 and Figure 12, and its location is represented by the orange line in Figure 4. The Chirp line continues across the western portion of the top terrace until it starts to decrease in elevation toward the western boundary of the bank. The strength of the seafloor reflection lessens toward the edge of the bank where the seafloor is deepest. At the top of the bank, the seismic signal penetrates approximately 10 meters; the depth of penetration increases to approximately 40 meters at the seafloor adjacent to the edge of the bank, allowing more reflectors to be observed. At the beginning of the line near the top of the terrace, the strong seafloor reflector is consistent with coarser sized sediments. The reflectors are tipped up toward the east, indicating uplift which can be seen in Figure 12. The reflector associated with the most recently deposited sediments lap on top of the tilted reflectors. Acoustic penetration is greater on the edge of the bank where softer sediments presumably exist. Some radial faulting is also visible at the western edge of the bank.

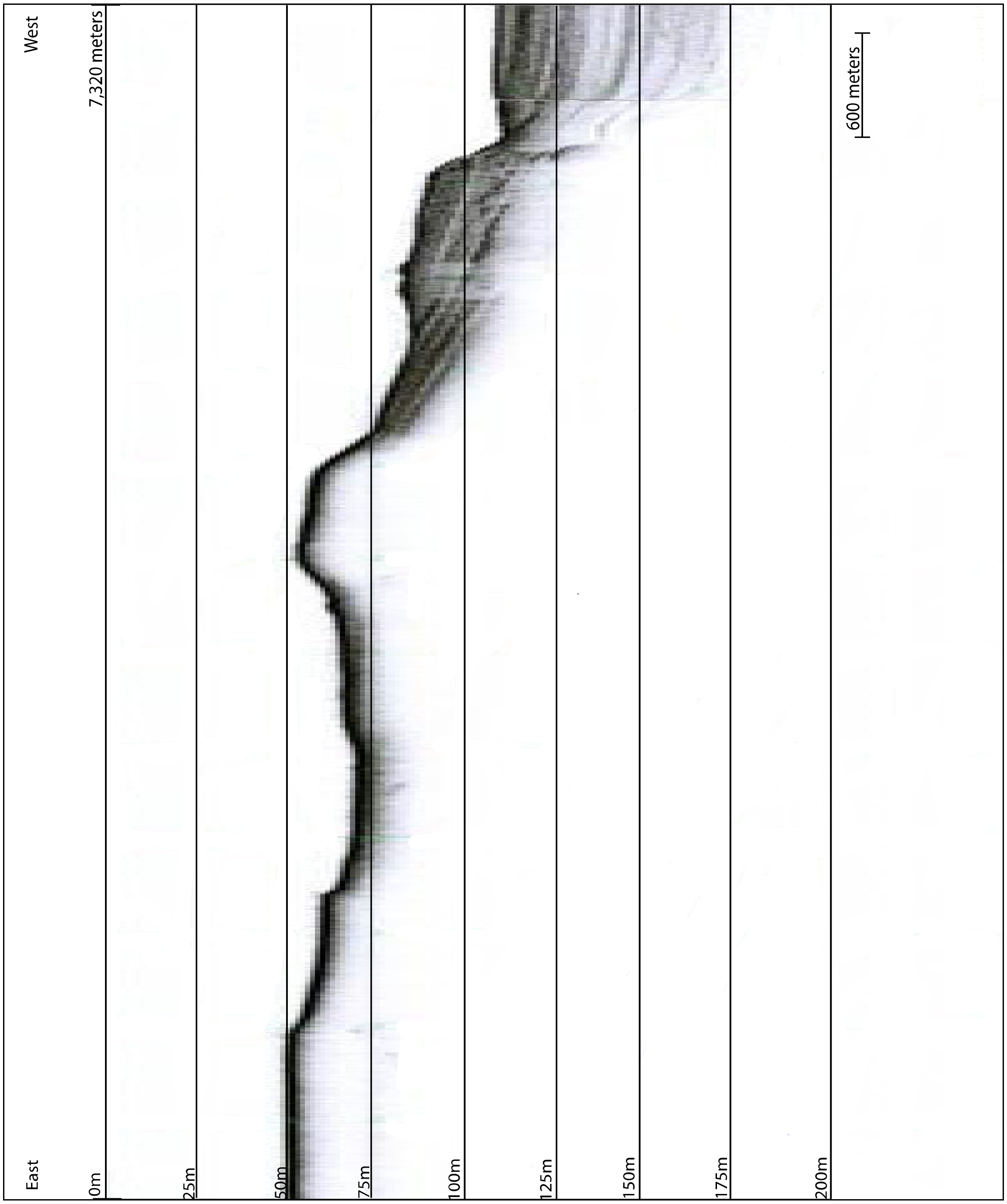


Figure 11: East to West Chirp2-b. Which is 7,320 meters in horizontal extent and the last section of Chirp2. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

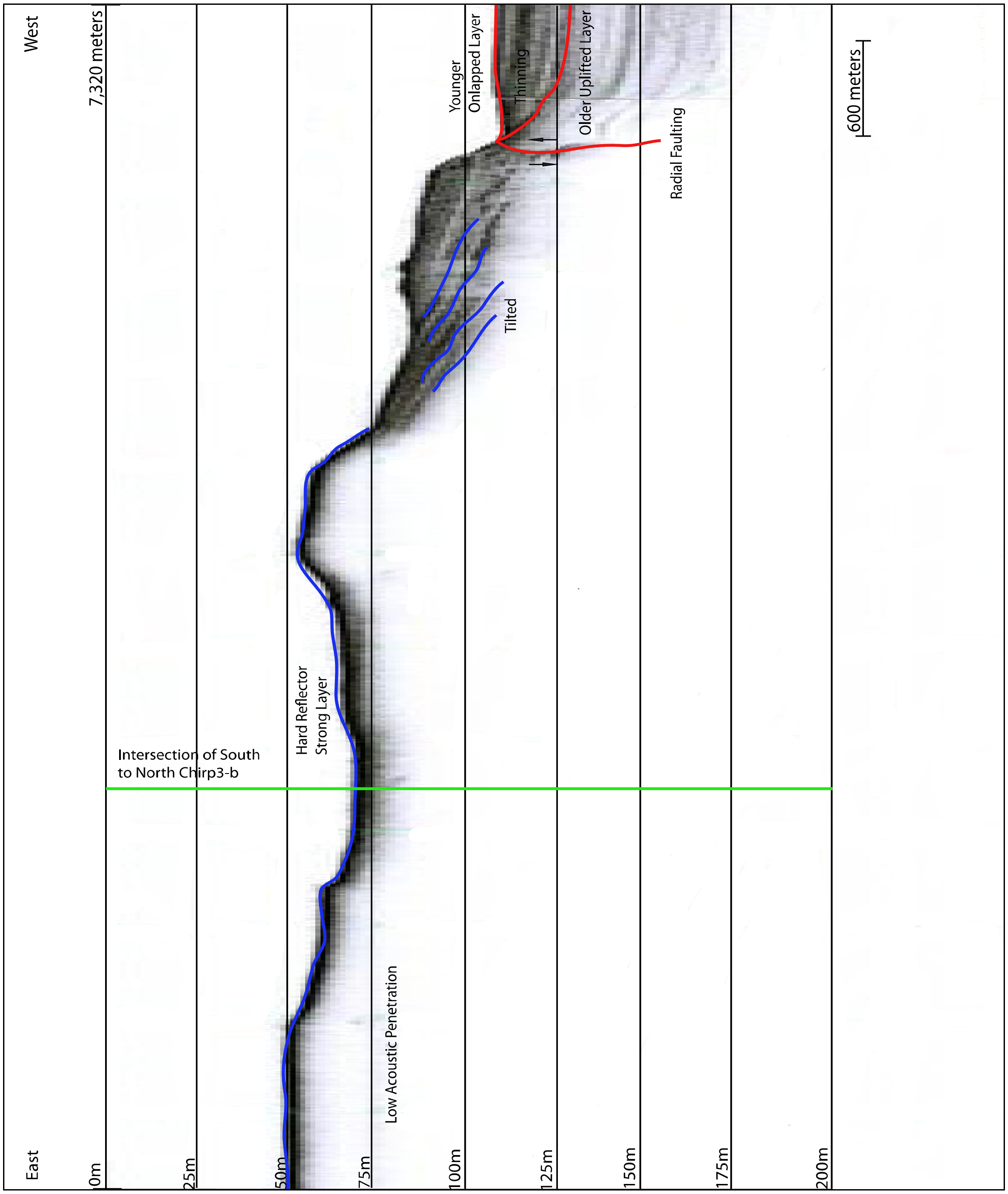


Figure 12: East to West Chirp2-b Interpreted. Which is 7,320 meters in horizontal extent and the last section of Chirp2. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

The S-N Chirp3 line is shown below in Figure 13 and Figure 14, and its location is represented on Figure 4 by the pink section of the line running south to north at longitude 90.58 °W. This section of the line was short due to the technical problems with the sub-bottom profiler. The slope on the seafloor surrounding the bank is very gradual and there is not significant elevation change in this line. Laterally continuous reflectors tip slightly towards the bank, with an acoustic penetration of approximately 50 meters. It is important to note that the deepest reflectors tip upward towards the bank edge, as would be the case with pronounced uplift due to salt diapirism. There is slight onlapping of the shallowest reflectors (most recently deposited sediments) onto the bank.

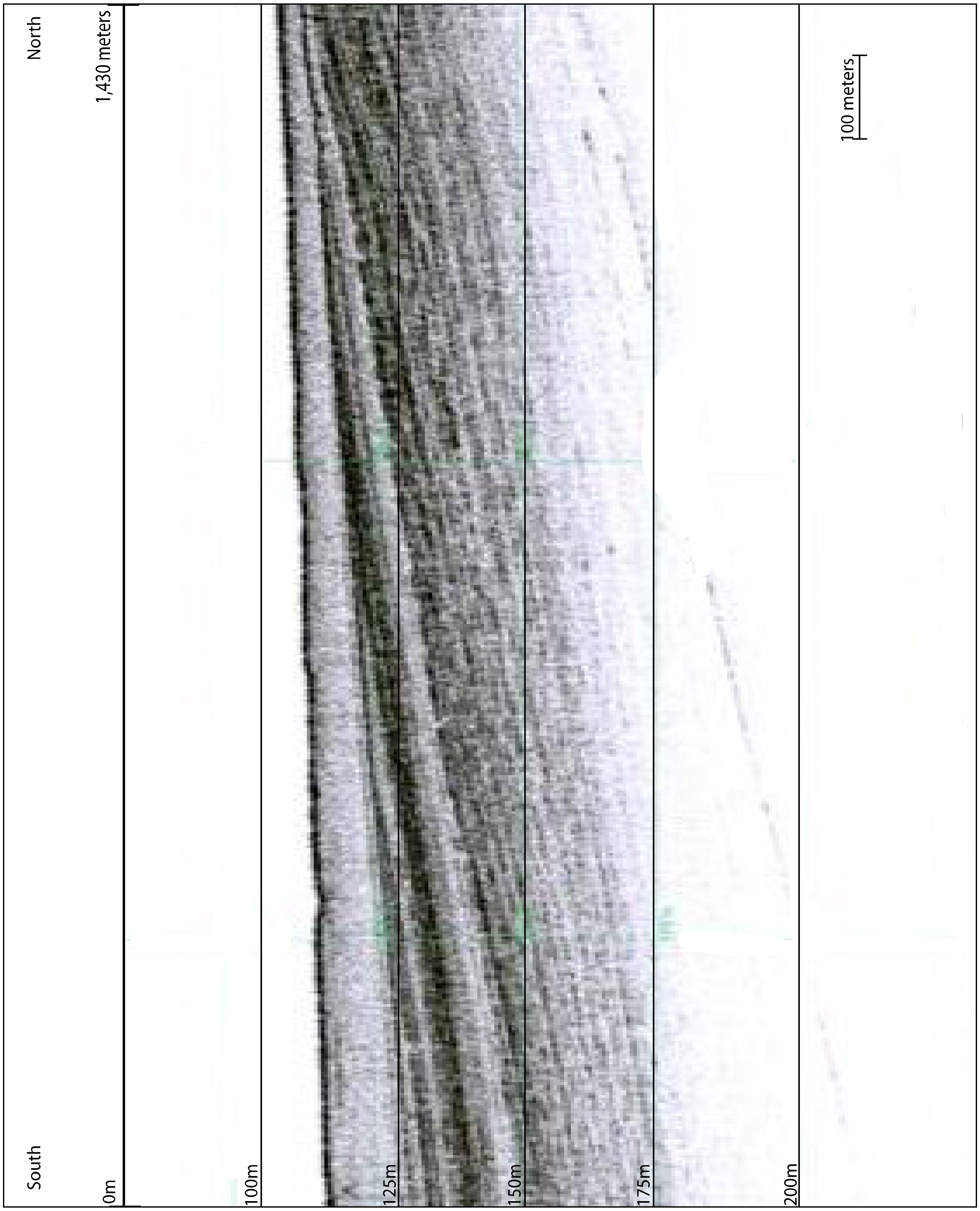


Figure 13: South to North Chrip3-a. Which is 1,430 meters in horizontal extent.
It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from two-way travel time presuming the sound velocity of 1500 m/sec.

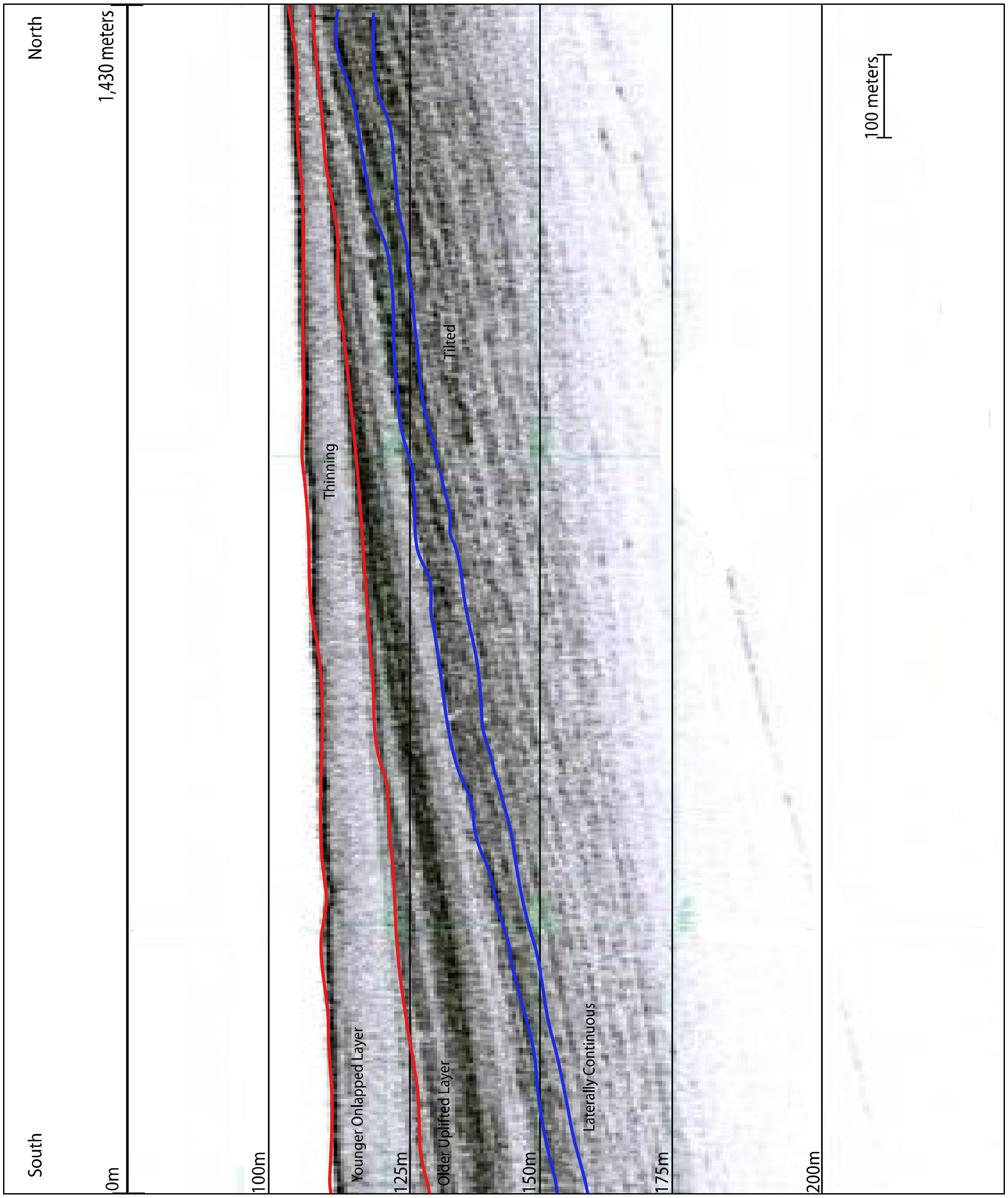


Figure 14: South to North Chrip3-a Interpreted. Which is 1,430 meters in horizontal extent. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from two-way travel time presuming the sound velocity of 1500 m/sec.

The next section of S-N Chirp3 line can be seen below in Figure 15 and Figure 16, and its location is represented on Figure 4 by the dark green line. The intensity of the seafloor reflection increases toward the top of the top terrace of the western section of the bank. This line extends across a limited portion of the bank and therefore does not show a pronounced elevation change. It has the same strong seafloor reflector seen on other profiles that cross the top terraces. Penetration decreases from approximately 40 meters on the edge of the bank to approximately 10 meters on the terrace. The reflectors corresponding to the younger sediments lap onto the edge of the bank and thin up dip towards the bank. The underlying reflectors are tilted and appear to be laterally continuous. The locations of Box Core 3 and Box Core 2 are visible on this Chirp line. Box Core 3 was taken near the base of the southern edge of the bank on the seafloor to provide a sediment sample of the seafloor surroundings adjacent to the bank's southern edge. Box Core 2 was taken near the top terrace in order to provide insight on the composition of the seafloor sediments there. As with previously described profiles, there is faulting is present and presumably due to the uplift of the bank by salt diapirism. There are also folded beds that can be seen near the location of Box Core 2, which are likely due to uplift at the top of the bank.

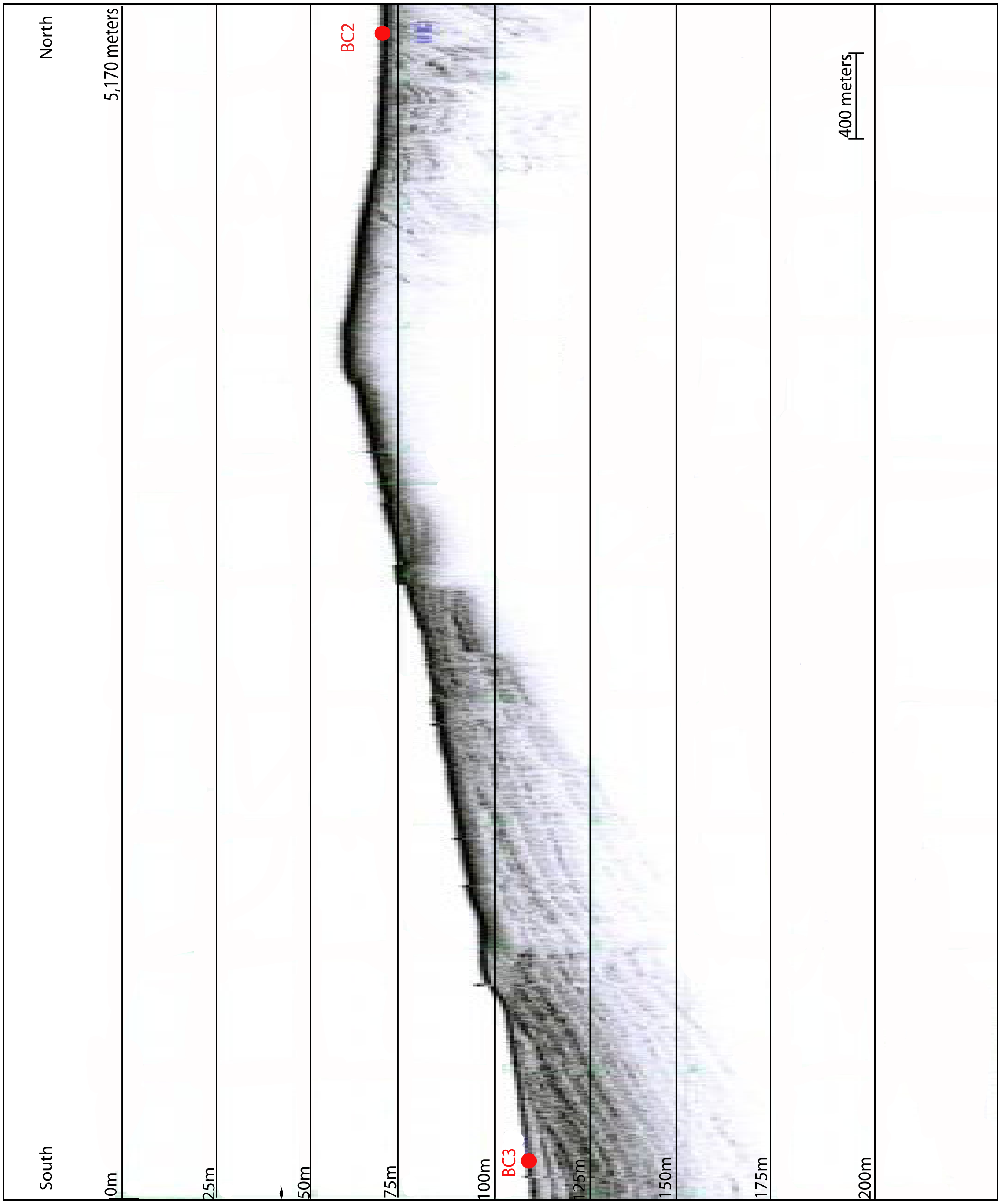


Figure 15: South to North Chirp3-b. Which is 5,170 meters in horizontal extent and shows the locations of BC3 and BC2. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

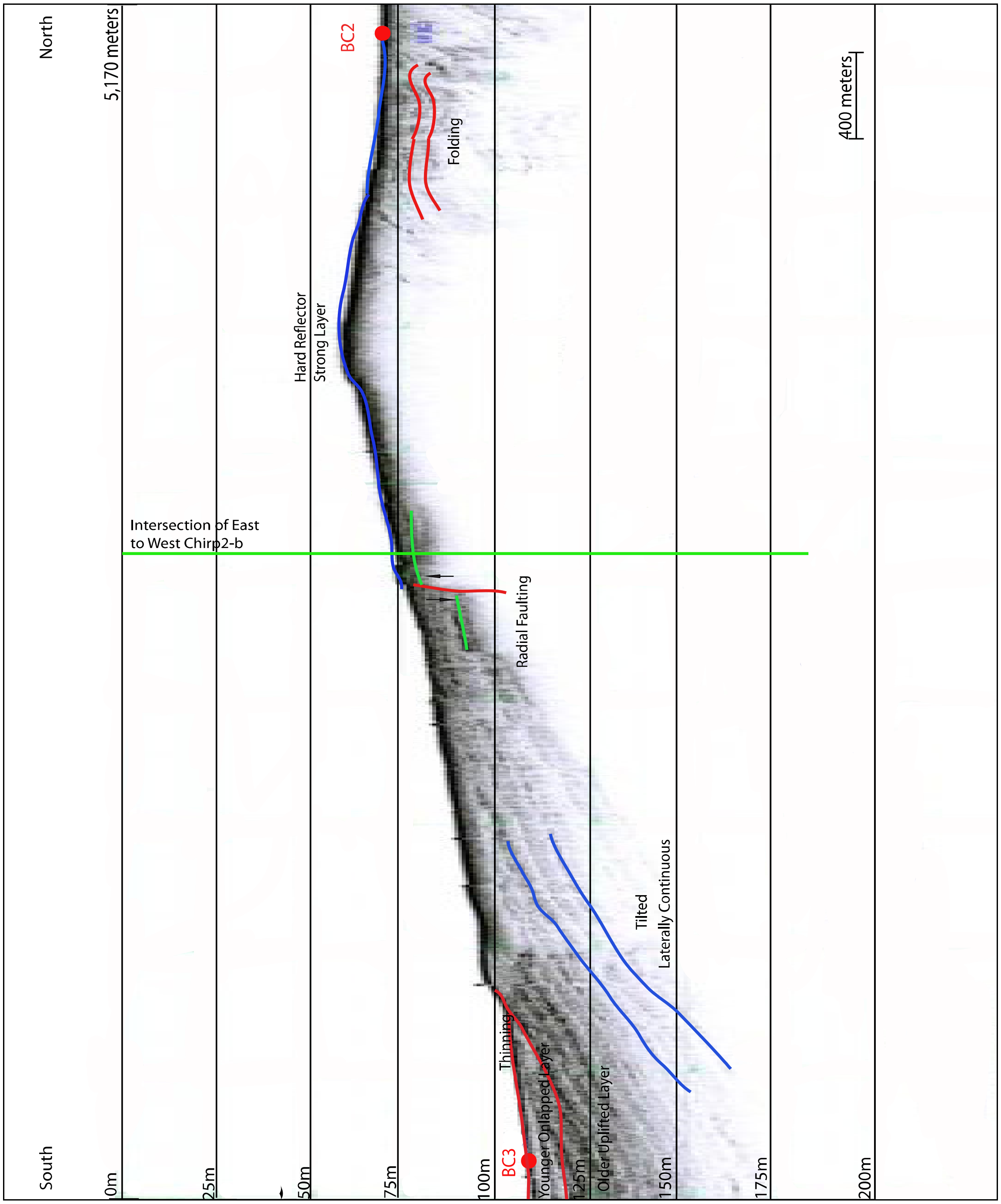


Figure 16: South to North Chirp3-b Interpreted. Which is 5,170 meters in horizontal extent and shows the locations of BC3 and BC2. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

The next section of S-N Chirp3 line is represented below in Figure 17 and Figure 18, and location is indicated by the dark blue line on Figure 4. This profiler line shows the water depth increasing from south to north. Lateral variations in the intensity of the seafloor reflector across the section may indicate variations in sediment composition or stiffness, with a stronger reflection corresponding to stiffer sediment or larger amounts of coarse sand or coral. It is possible that the shallow seabed sediments of the middle terrace are weak but in places their surface is draped by coarser materials derived from the top terraces, giving it a hard surface reflection. The northern end of this line shows the transition in depth from the bank edge to the seafloor surrounding the bank. The patterns of reflectors indicate tipped beds on the north side of this bank; and onlap occurs with thinning towards the bank. Acoustic penetration is approximately 20 meters on the terrace and increases to 40 meters at the edge of the bank, indicating sediments there are weaker and/or composed of finer-sized sediment grains. In the middle of this profile there are signs of possible gas pockets (indicated by blue lines on Figure 18)

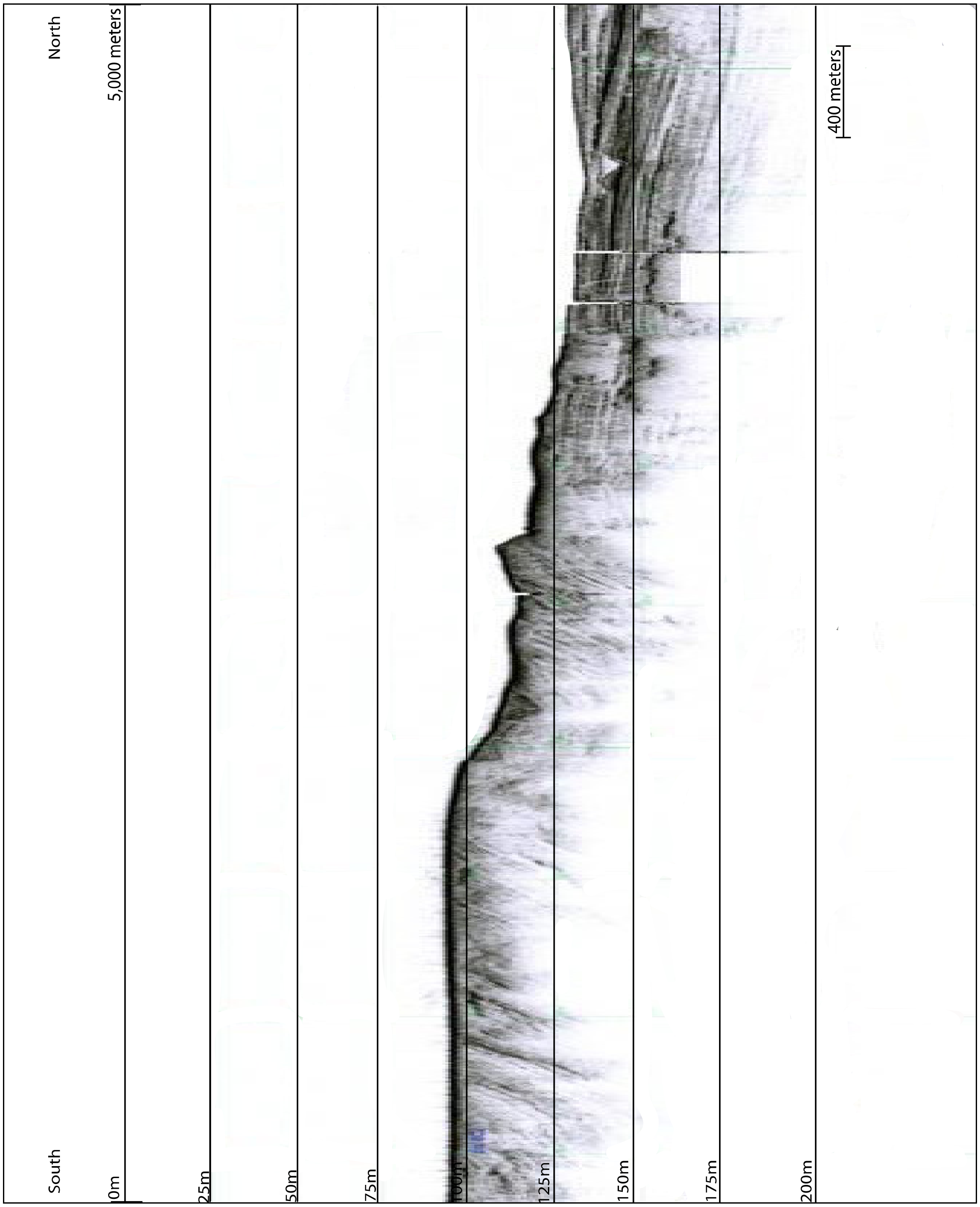


Figure 17: South to North Chrip3-c. Which is 5,000 meters in horizontal extent. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

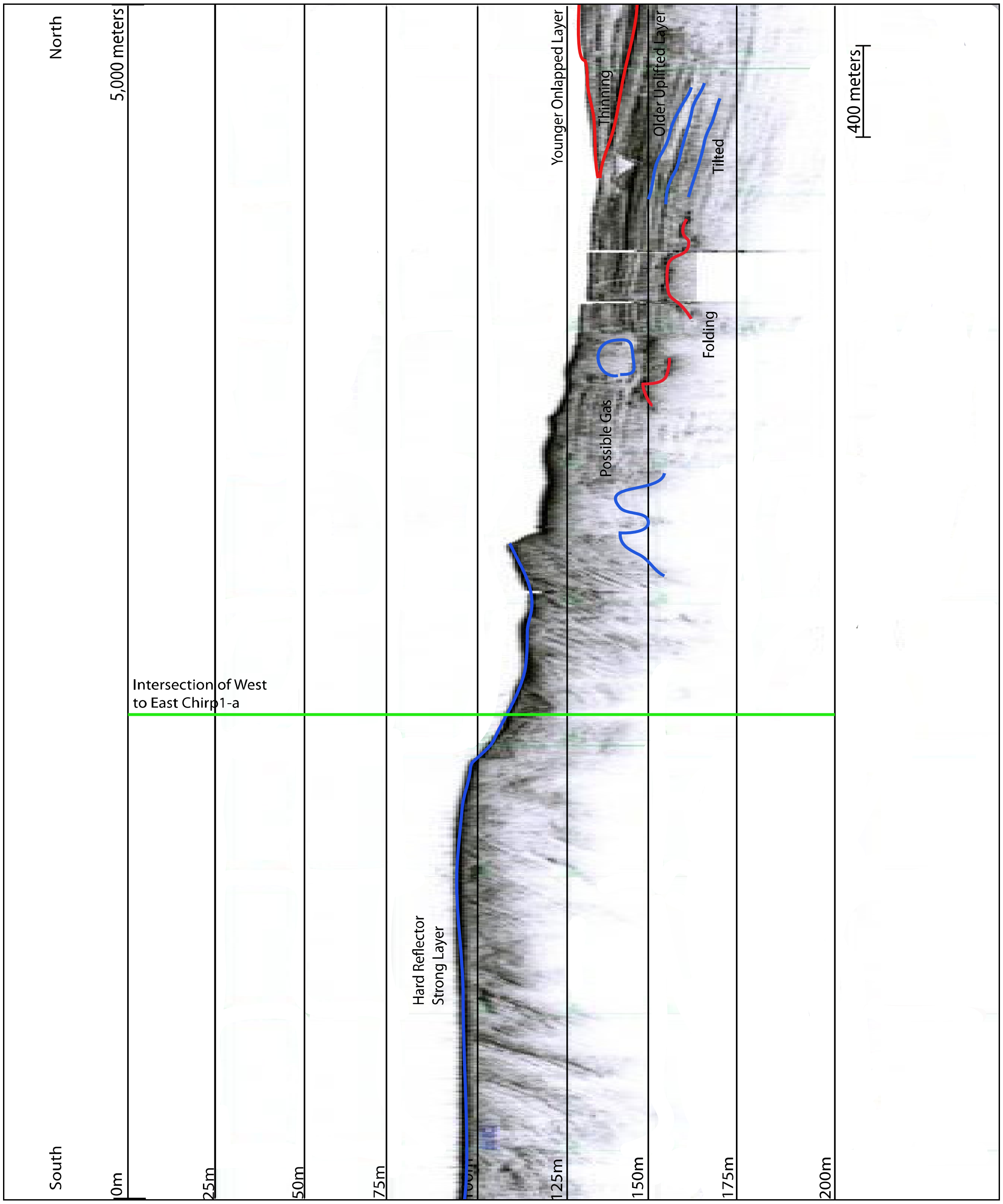


Figure 18: South to North Chrip3-c Interpreted. Which is 5,000 meters in horizontal extent. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec. Interpreted.

The last section of S-N Chirp3 line is show in Figure 19 and Figure 20, and it location is on Figure 4 by the marine green line. It corresponds to the seafloor at the north side of the bank. Little to no elevation change is evident and the seafloor reflection is neither as thick nor dark as the seafloor reflection that occur on the terraces, which indicates softer sediments in the seabed adjacent to the bank (note acoustic penetration is approximately 50 meters). The pattern of reflectors indicate sediment beds are tipped due to the uplift of the bank and the younger sediments lap onto the bank edge and thin towards the bank. The underlying, older sediment layers are laterally continuous and exhibit consistent reflection intensities, with the exception of some pockets of possible gas. Box Core 1 is visible in this Chirp line and was taken on the north side of the bank in order to investigate the nature of the seafloor sediment at the northern edge of the bank.

A noteworthy feature is observed on this profile – the presence of a known pipeline is indicated in Figure 20. The reflections around its edges are artifacts of the wide acoustic beam produced by the seismic profiler, and the pipe's presence has resulted in lower acoustic penetration.

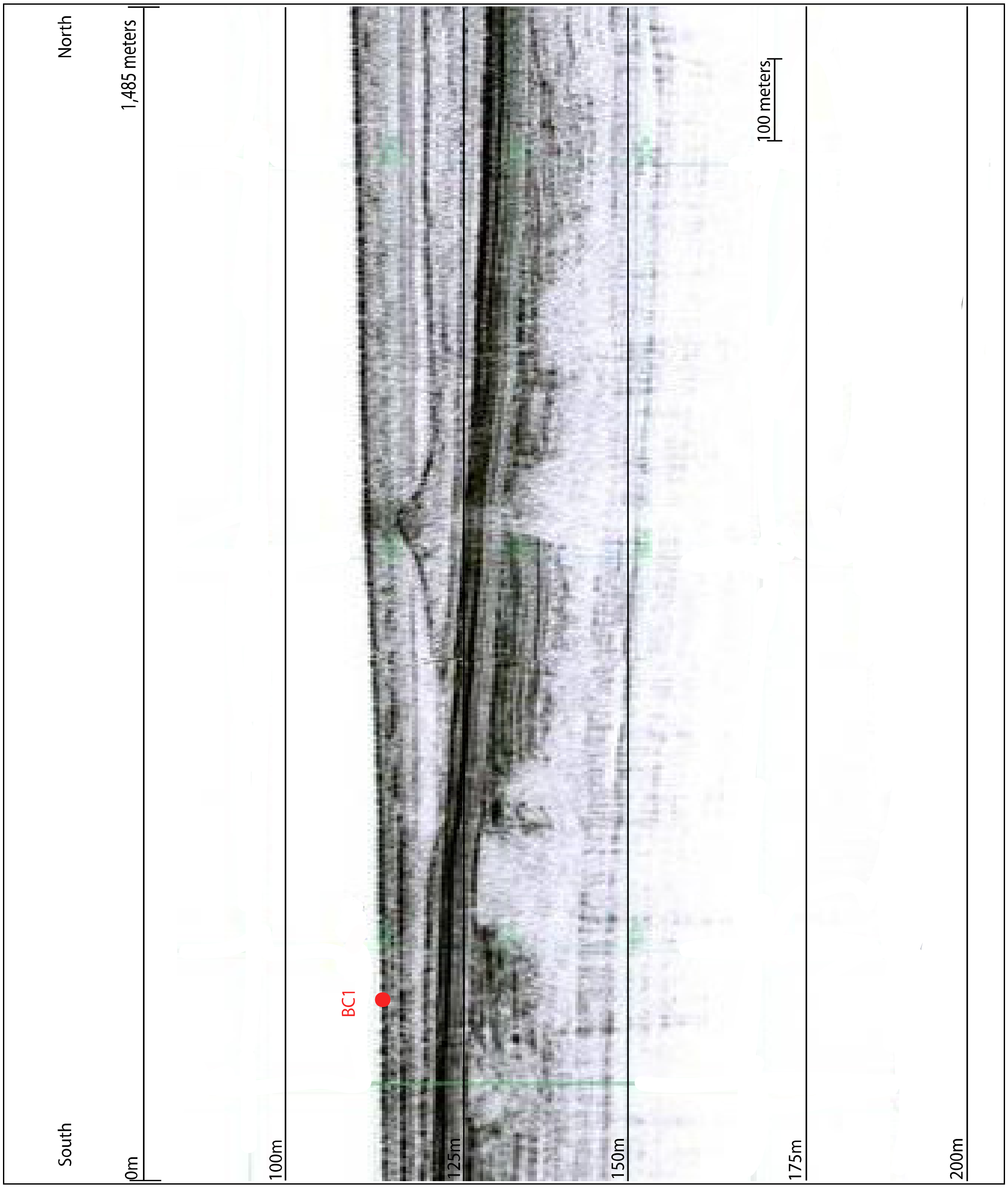


Figure 19: South to North Chirp3-d. Which is 1,485 meters in horizontal extent and shows the location of BC1. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

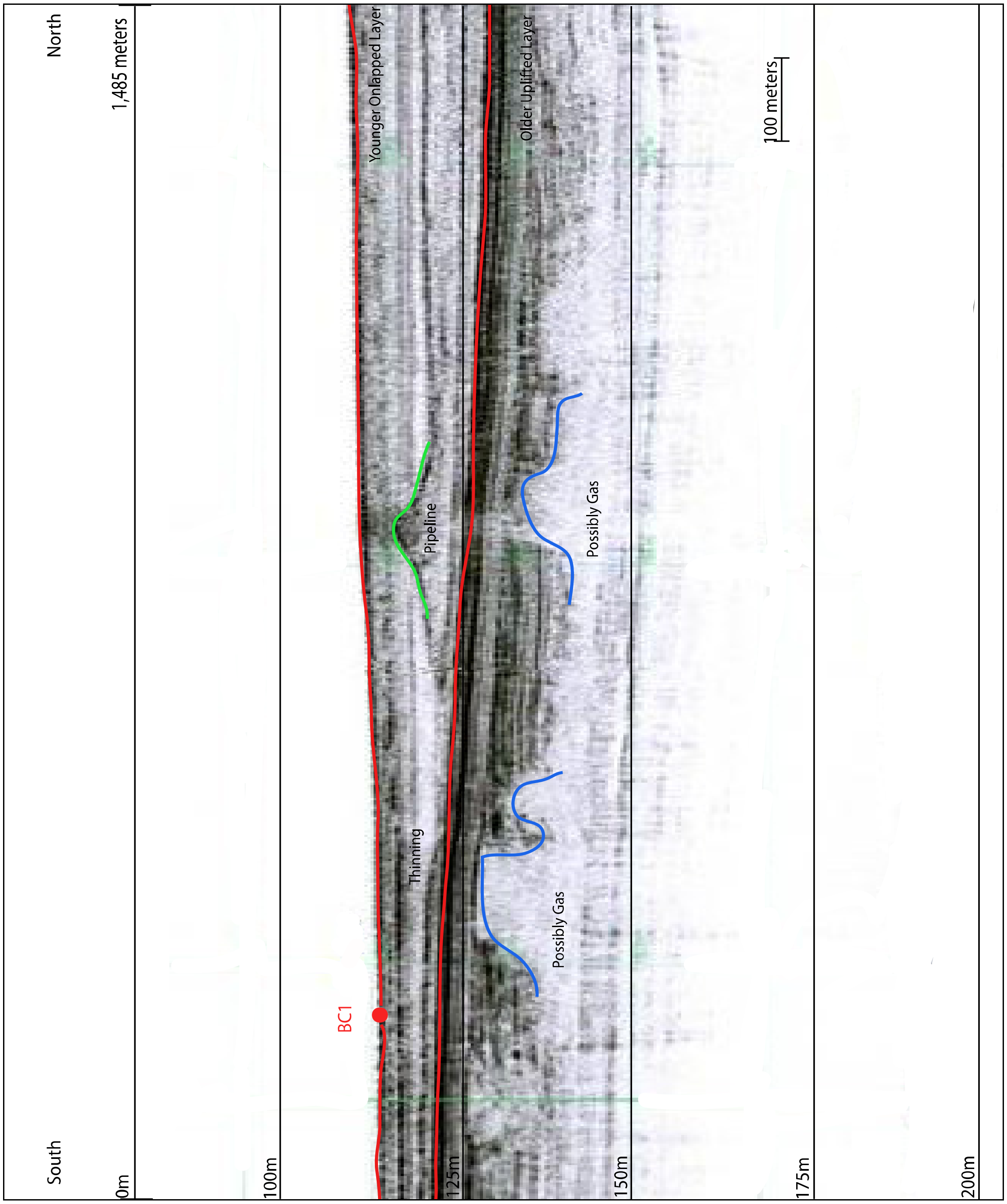


Figure 20: South to North Chirp3-d Interpreted. Which is 1,485 meters in horizontal extent and shows the location of BC1. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

N-S Chirp4 line below in Figure 21 and Figure 22, and its location is represented on Figure 4 by the red line. The line was taken from the north to the south on the eastern side on the bank and is the best image collected by the sub-bottom profiler. Elevation gradually increases from the north to the south and the surface reflection becomes thicker and more intense at the middle terrace; this reflection even more intense at the top terrace. Acoustic penetration ranges from approximately 50 meters on the edges of the bank to approximately 10 meters on the top terraces. These variations suggest coarser and/or stiffer sediments occur at the top terrace. At the southern edge of the bank, the patterns of reflectors indicate the sediments deposited most recently on the adjacent seafloor lap onto the bank edge and thin towards the bank. The underlying, older layers are tipped, indicating earlier uplift of the bank.

This image shows a collapse has occurred between the terraces and the surface of the resultant depression (indicated by a strong reflector) has been covered by younger sediments. Abundant faults occur in this area. Their presence suggests uplift of the bank produced tensional features such as radial faulting.

On the south side of this line, the beds tip down in a seaward direction, which is toward the edge of the continental slope where the seafloor is deeper. The pattern of reflectors on this one continuous image clearly shows sediments lapping from the surrounding seafloor onto the edges of the bank and strong seafloor reflections occur at the bank's highest elevations. The locations of Box Core 4 on the middle collapsed terrace of the bank and Box Core 5 on the seafloor surrounding adjacent to the southern edge of the bank are indicated on the profile.

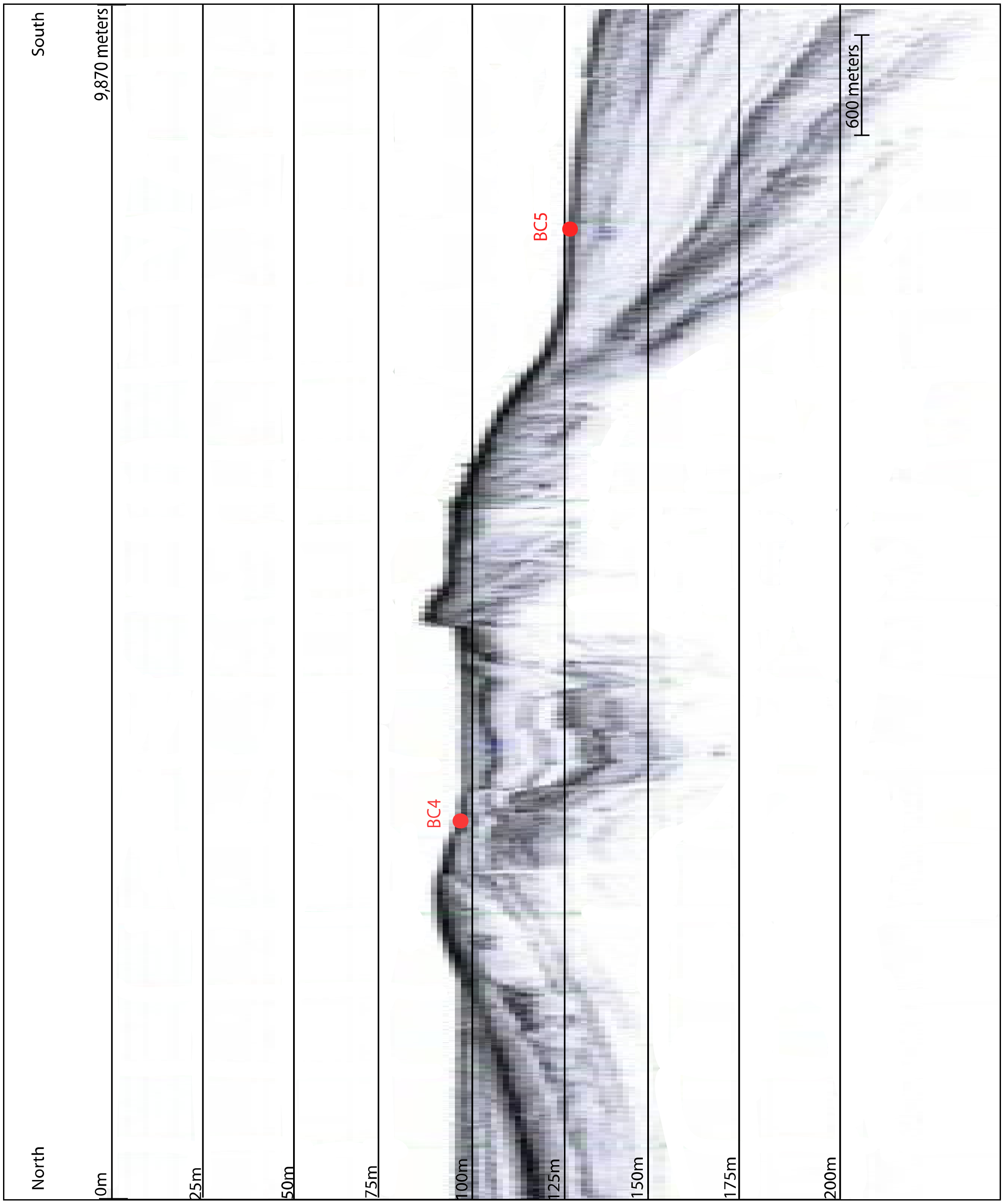


Figure 21: North to South Chirp4. Which is 9,870 meters in horizontal extent and shows the locations of BC1 and BC5. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

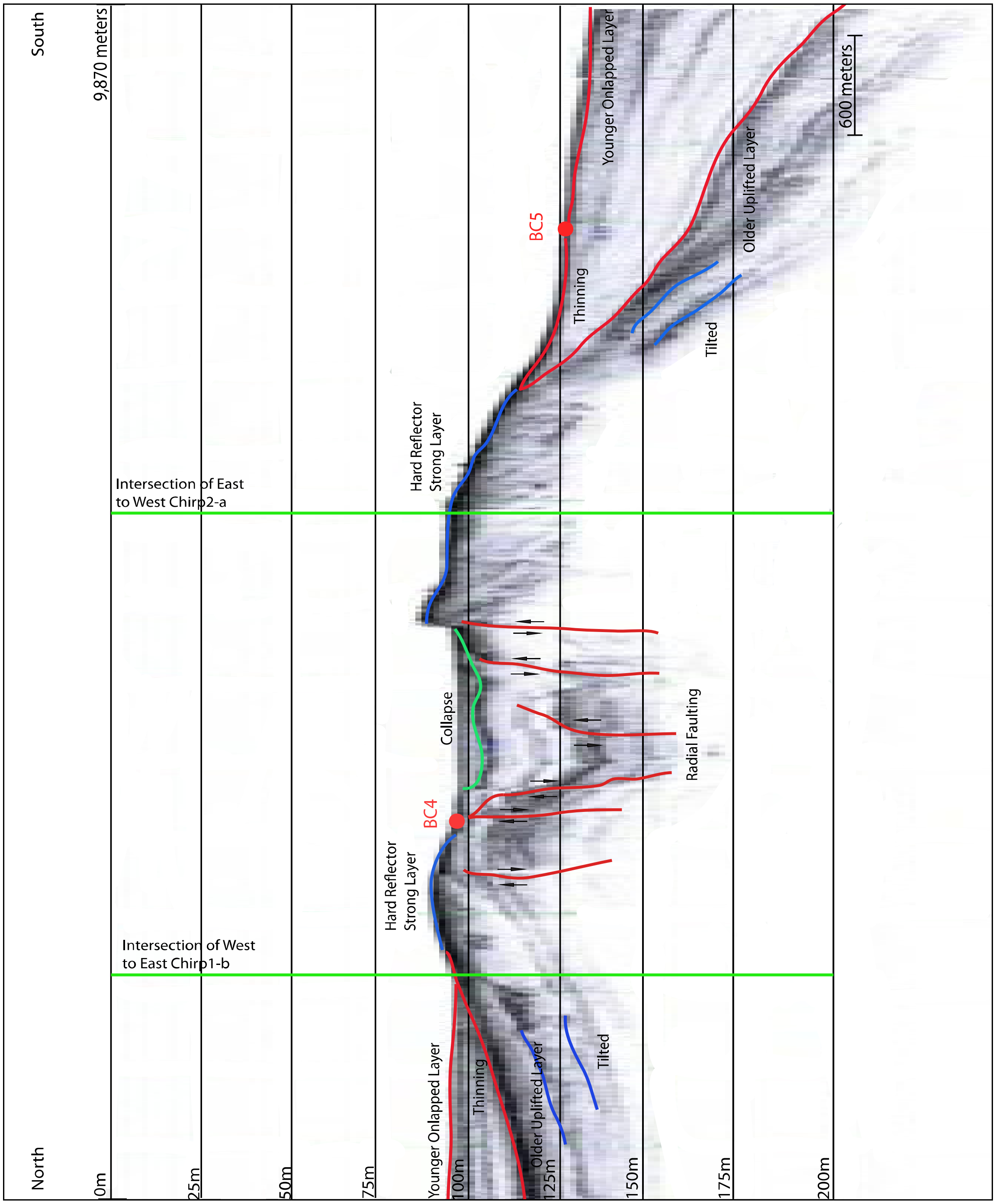


Figure 22: North to South Chirp4 Interpreted. Which is 9,870 meters in horizontal extent and shows the locations of BC1 and BC5. It was collected at 2.5 to 4.0 kHz with a pulse length of 15 milliseconds, and the depths are estimated from the two-way travel time presuming the sound velocity of 1500 m/sec.

5. GEOLOGIC CORES

5.1 Methods – Box Core

Geologic cores are the basis of determining geologic characteristics due to the tangible evidence they provide about the sediment. They are especially useful in geological oceanography where it is not always easy to directly study the seafloor. By obtaining cores, personnel are then able to better understand the area of interest. The processes of obtaining geologic cores have developed greatly over the years allowing researchers to obtain samples from deeper and more remote locations than ever before.

The collection of sediment samples at this location was accomplished by using box cores on the *RV Gyre*. The Box Core rig consists of hardware assembled together into a working core rig that will be deployed to the seabed for collecting a cubic box core. The box core design used was originally developed by Joe Grey and Frank O'Hara in the Department of Oceanography at Texas A&M University and is referred to as the Gulf of Mexico corer (Boland, et al., 1991), and has since then been adopted by TDI-Brooks for use in various sizes, Figure 23. The Box Cores that were used in this study were 0.5m x 0.5m x 0.5m, also known as 0.5-meter deep box cores.

Figure 23: TDI-Brooks Box Coring Rig. Left-50cm x50cm x50cm, Right-1meter x50cm x50cm.

To use a 0.5-meter stainless steel box cores for undisturbed, superficial sediment sampling for geological sampling: The Box Core was rigged to the main coring rope with a proper shackle, and the trigger assembly was set for deployment. The main winch, main coring rope, and starboard A-Frame were used for deploying and retrieving the box corer. In addition to the deployed hardware, there was support gear mounted to the vessel working deck to manage the deployment and retrieval of the coring rig. These included items such as track/bucket/heel block and a main sheave from the starboard A-Frame. Once the box corer was safely deployed it was lowered to the seabed while maintaining navigation protocols and then a core was acquired.

When retrieval occurred on the deck the box core was secured with a safety pin in the enclosed position and placed on its stand and secured to the deck. The lid was opened and the contents inspected for quality and acceptability of the sample. The overlaying water was siphoned off to expose the sediments for sub-sampling. One set of 3 inch diameter push tubes were retrieved from the box cores. They were labeled, capped, taped with appropriate colors for top and bottom, and had their void spaces filled to prevent disturbance and offloaded at the next port call. They were then transported to Texas A&M personnel for further analysis.

5. 2 Results – Box Core

The five box cores for this project were taking on 27 May 2012 and 28 May 2012 by the *RV Gyre*. The locations of these cores are represented in Table 1 and the field notes are presented in Table 2.

Table 1: Box Core Reported Locations.

CoreID	Lat-WGS84	Lon-WGS84	Y-UTM15N	X-UTM15N
EB_BC1	N28 08.670002000	W091 00.786609000	3114805.76	695116.67
EB_BC2	N28 06.133090000	W091 00.786598000	3110120.32	695193.30
EB_BC3	N28 03.490845000	W091 00.786579000	3105240.37	695273.02
EB_BC4	N28 06.294817000	W090 57.010193000	3110521.69	701373.00
EB_BC5	N28 03.949998000	W090 57.010137000	3106190.96	701446.06

Table 2: Field Descriptions for Box Cores.

Core	Recovery	Grain Size	Sorting	Color	Notes
BC1	15" then	Fine Clay	Well	Lt. Brown	brown clay at top
	gray				8" down turns to
BC2	6"	Sub-angular	V. Well	White Gray	Low penetration due
		Sand and		Brown, Tan	to sand layer
		Shell hash			
BC3	12"	Fine Clay	Well	Lt. Brown	Orange present as
					well as black pockets
BC4	18"	Fine Clay	Well	Lt. Gray	Contained large
					amounts of organic
dark					~4" down with a
					brown top layer
BC5	15"	Fine Clay	Well	Lt. Brown	Similar to BC1
				to Gray	

The description of the cores upon examination in the laboratory is below and the field photos are shown in Figure 24, Figure 25, Figure 26, Figure 27, and Figure 28.

Box Core 1 (15” of recovery) contains fine clay that is well sorted and can be described as a 2.5Y 7/2 Light Gray that changes to a 2.5Y 6/2 Light Brown Gray after the first 9”. Water content and cohesion are considered to be medium. There are several dark black blotches that appear within the 3” to 9” range below the surface line, which are likely organic streaks or shell hash.

Box Core 2 (6” of recovery) contains sub-angular shell sand with shell hash that is well sorted and can be described as a mostly 2.5Y 6/2 Light Brown Gray with mixed amounts of 10YR 6/1 Gray, 10YR 2/1 Black, 10YR 8/1 White, and 10YR 7/4 Very Pale Brown. Water content and cohesion are low.

Box Core 3 (12” of recovery) contains fine clay that is well sorted and can be described as a 2.5Y 6/2 Light Brown Gray that changes to a 2.5Y 5/1 Gray 5” below the surface line. The water content and cohesion is medium. There is some 5YR 7/8 Reddish Yellow staining in the top 3” of sediments in the core.

Box Core 4 (18” of recovery) contains fine clay that is well sorted and can be described as a uniform 2.5Y 6/2 Light Brown Gray. Water content and cohesion are medium. A few dark black blotches that appear within the 5” to 9” range below the surface line, which are likely organic streaks or shell hash.

Box Core 5 (15” of recovery) contains fine clay that is well sorted and can be described as 2.5Y 7/2 Light Gray. Water content and cohesion are medium. Sediments in this core appear to be very similar to the top section of Box Core 1 below the change to Light Brown Gray.

All colors expressed here are from “Earth Colors: A guide for soil and Earthtone Colors”.

Figure 24: Box Core 1.

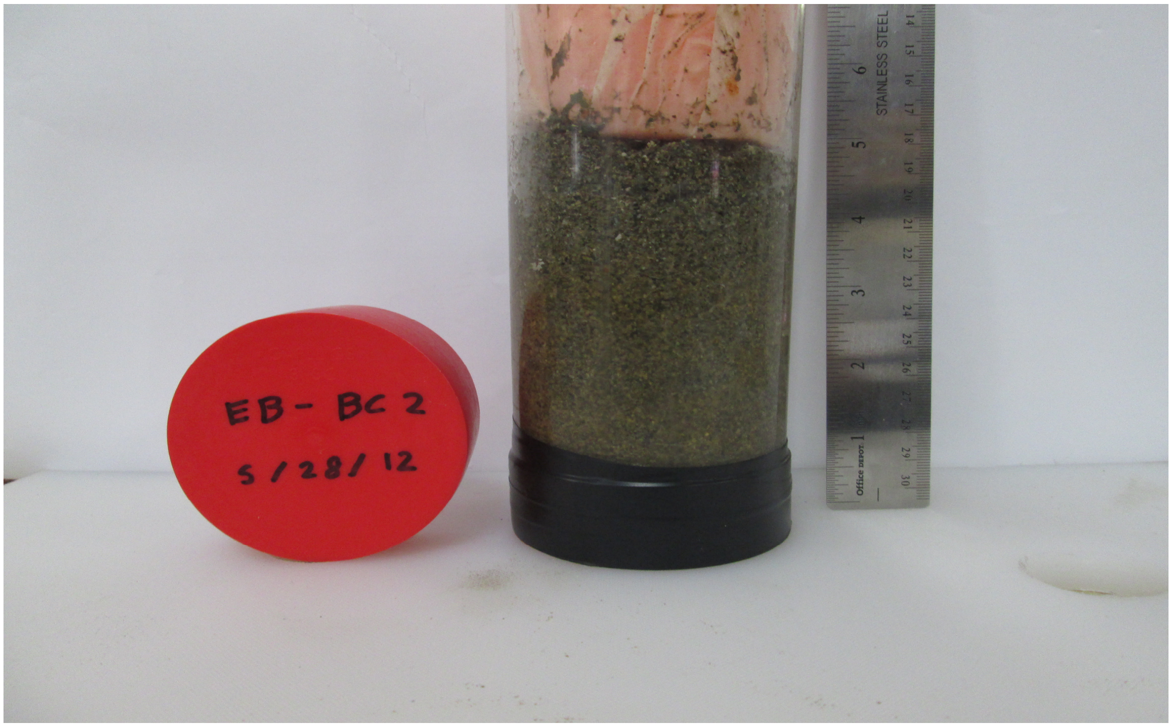


Figure 25: Box Core 2.

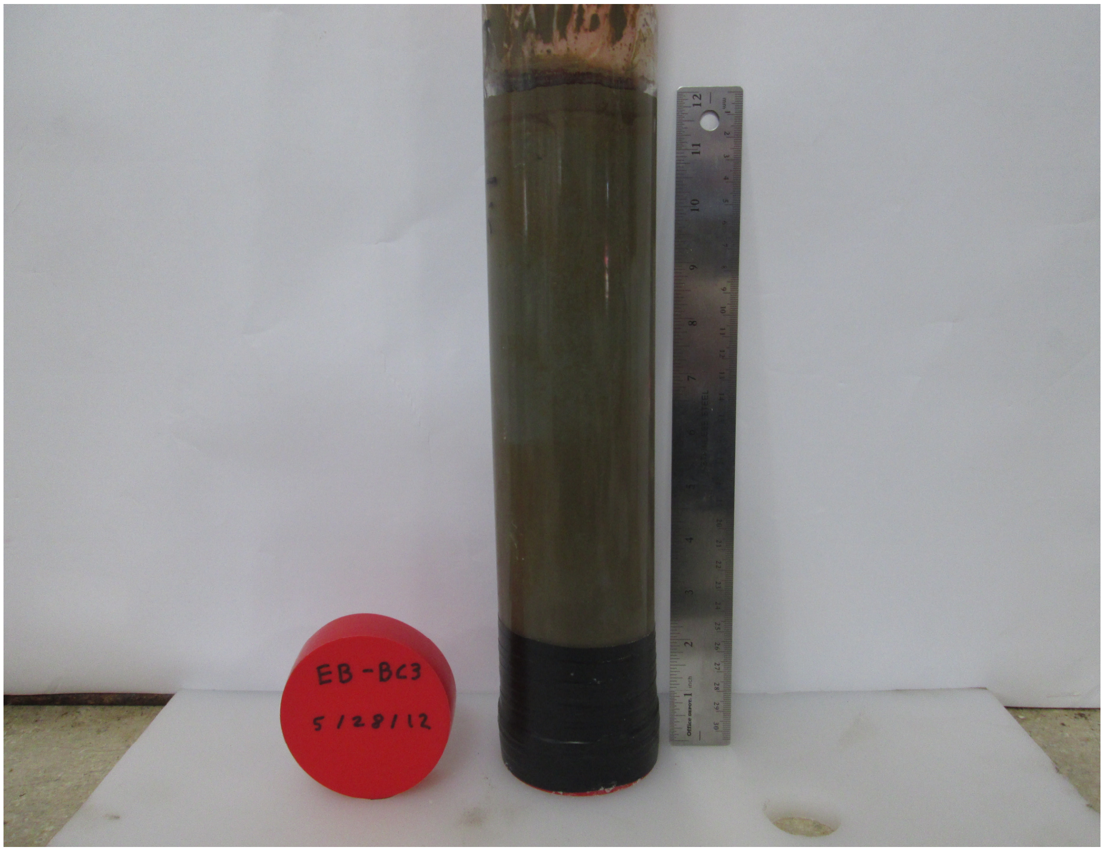


Figure 26: Box Core 3.

Figure 27: Box Core 4.

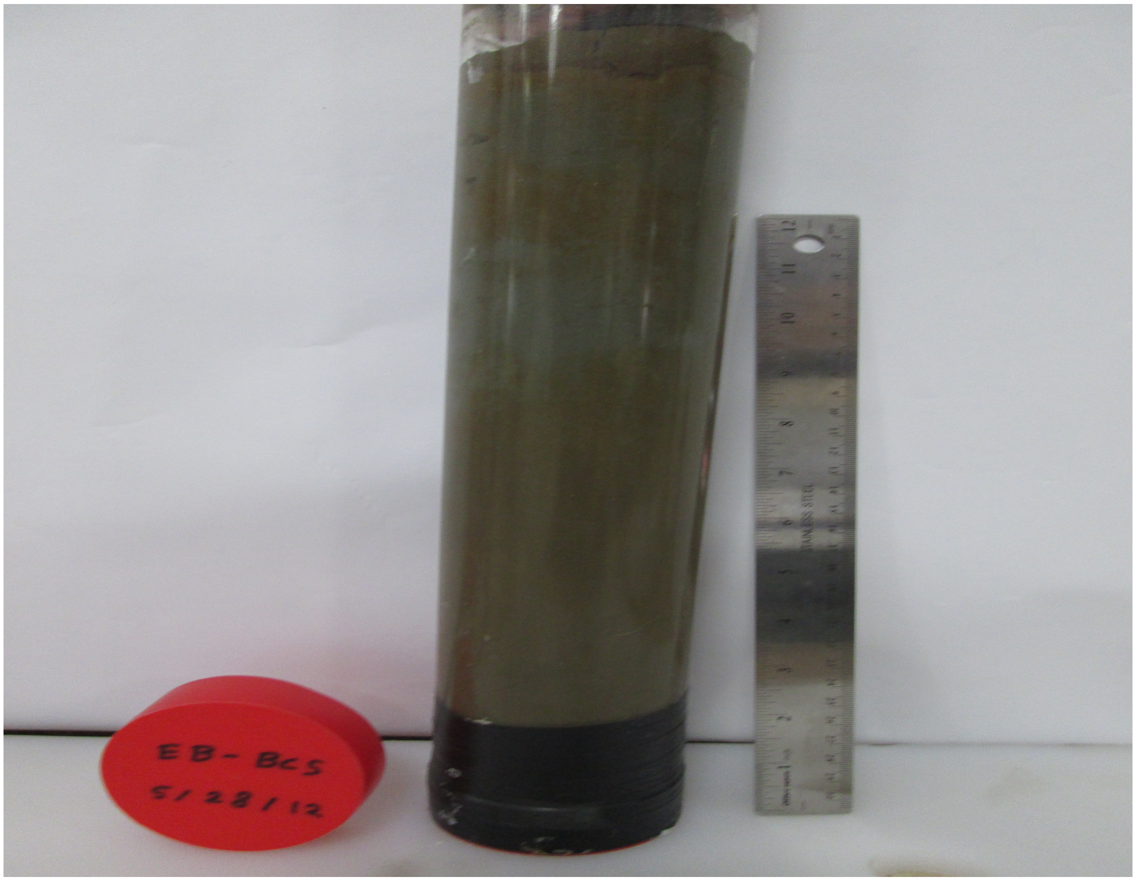


Figure 28: Box Core 5.

Figure 29: Box Core 1 Extruded and Split.

Box Core 1, shown above in Figure 29, is fine clay that is well sorted and produced 15” of recovery but was compressed to 14” upon extrusion. It becomes more consolidated and finer clay as it increases in depth. Contrary to the description provided from the liner. When split it appears to stay 2.5Y 7/2 Light Gray through out the entire section. The water content decreases after the first 7” and the sediment in the last 7” has high cohesion.

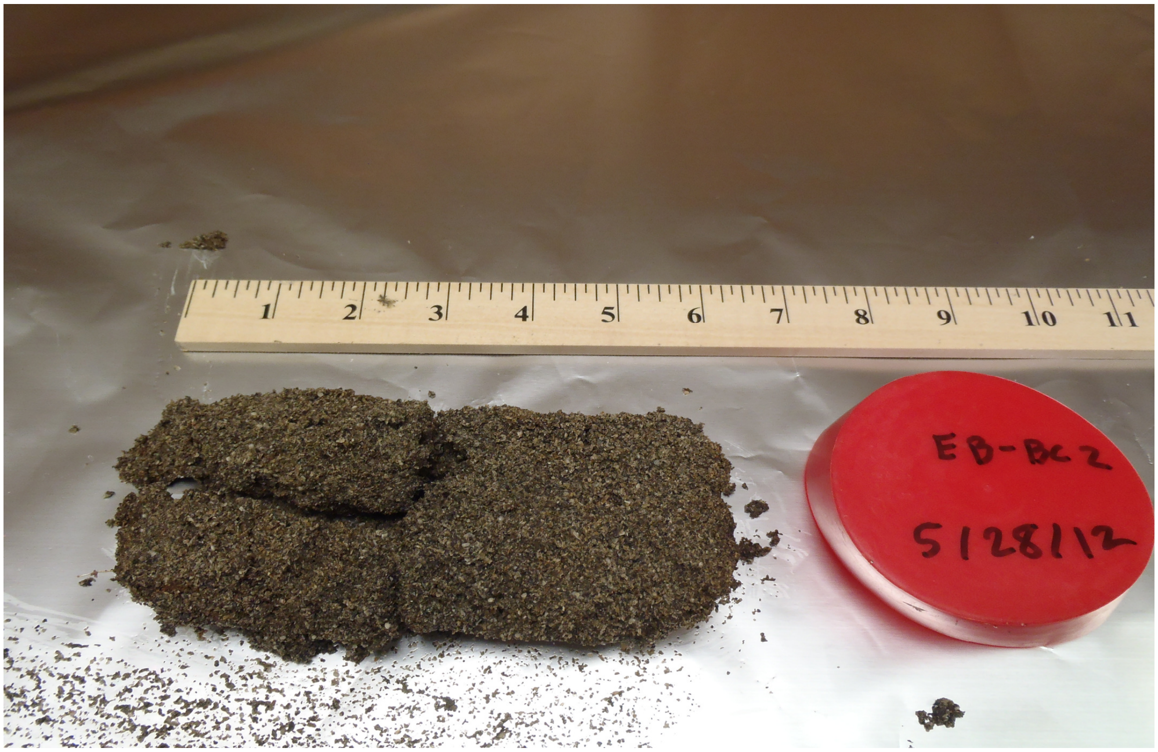


Figure 30: Box Core 2 Extruded and Split.

Box Core 2, shown above in Figure 30, is sub-angular shell sand with shell hash and is very well sorted but produced little recovery at only 6”. It can be described as a mostly 2.5Y 6/2 Light Brown Gray with mixed amounts of 10YR 6/1 Gray, 10YR 2/1 Black, 10YR 8/1 White, and 10YR 7/4 Very Pale Brown. There is low water content, low cohesion, and is no change in the core throughout its 6” of sample.

Figure 31: Box Core 3 Extruded and Split.

Box Core 3, shown above in Figure 31, is fine clay that is well sorted and produced 12” of recovery. It can be described as a 2.5Y 6/2 Light Brown Gray that changes to a 2.5Y 5/1 Gray at 5” below the surface line. There is medium water content and medium cohesion in the upper 8” of this sample, however, the bottom of the sample increases in cohesion to high for the last 4”. There is some 5YR 7/8 Reddish Yellow staining in the top 3” of recovery. Pieces of shell can also be observed mixed in this sample in the first 2” and at the bottom near 11”. This was a difficult sample to split due to the strength of the sediment and the high cohesion.

Figure 32: Box Core 4 Extruded and Split.

Box Core 4, shown above in Figure 32, is fine clay that is well sorted and produced 18” of recovery. After extrusion the sample was compressed to 14”. It can be described as a 2.5Y 6/2 Light Brown Gray and is very uniform throughout the 18”. There is medium water content and high cohesion through the entire core. There are few dark black blotches that appear within the 11” to 14” range below the surface line. These are likely organic streaks or shell hash. This sample was the hardest of the 5 to extrude, which can be a result of sediment strength or high cohesion.

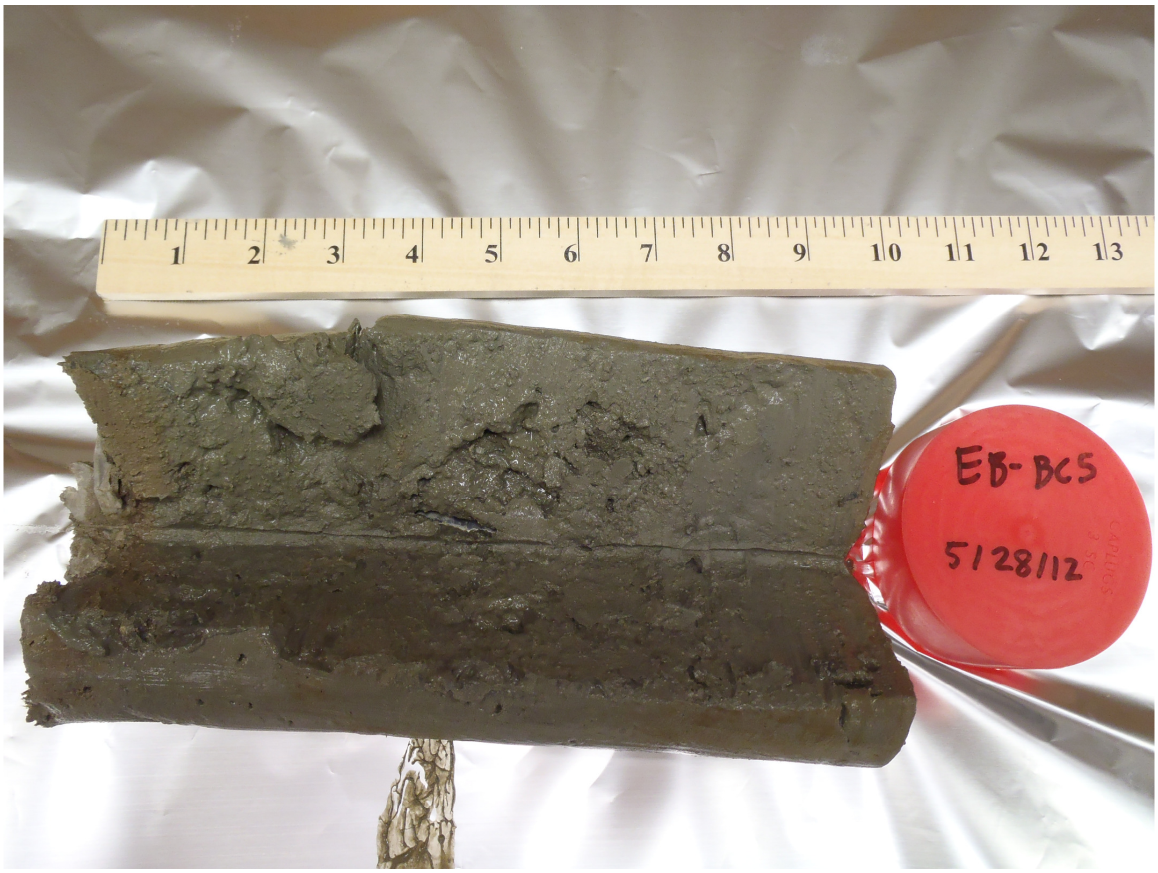


Figure 33: Box Core 5 Extruded and Split.

Box Core 5, shown above in Figure 33, is fine clay that is well sorted and produced 12” of recovery in this push tube but compression by extrusion caused this to produce 10”. It can be described as 2.5Y 7/2 Light Gray. There is medium water content and medium cohesion. It appears to be very similar to the top section of Box Core 1 in color, but more similar to Box Core 3 in recovery. This was a difficult sample to split due to the strength of the sediment and the cohesion of the sediment.

5.3 Methods – Miniature Vane

A standard miniature vane instrument (Figure 34), also known as a minivane, was used to measure the torque on sediment using a calibrated spring in order to calculate undrained shear strength of fine grained soils (ASTM D4648, 2011). To operate this device, a vane is then lowered into the sediment sample to a depth of 2 inches. The machine is then turned on and the difference between the starting dial number and the number at finish is recorded, indicating the angle of rotation at which the sample shears. Given the angle and the torque of the spring, the shear strength of the sediment can be calculated. In the case of this study the results indicate differences in the composition and stiffness of the sediments in the box core samples that reflect the geologic histories of the sediments at various locations on the Ewing Bank.

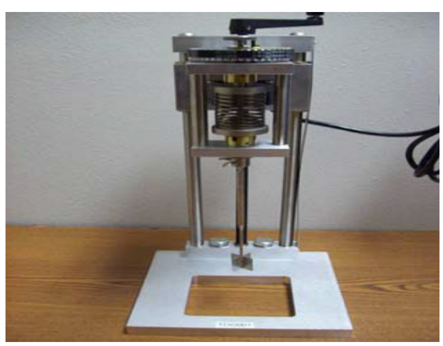


Figure 34: Miniature Vane Instrument. With a standard 1” x 1” blade on a 4” extension and spring ready for use.

5.4 Results – Miniature Vane

The results from this experiment on the box core samples are shown plotted in Figure 35 below. Box Core 1 had strength of 135.5 psf (pounds per square foot) and is classified as very soft sediment. Box Core 2 contained to large a quantity of sand and shell hash for an accurate minivane reading to be obtained. Box Core 3 had strength of 514.9 psf and is classified as firm sediment. Box Core 4 proved to be identical in its strength to Box Core 3 with strength of 514.9 psf and was classified as firm sediment as well. The last of the Box Cores, Box Core 5, had strength of 284.5 psf and is classified as soft sediment.

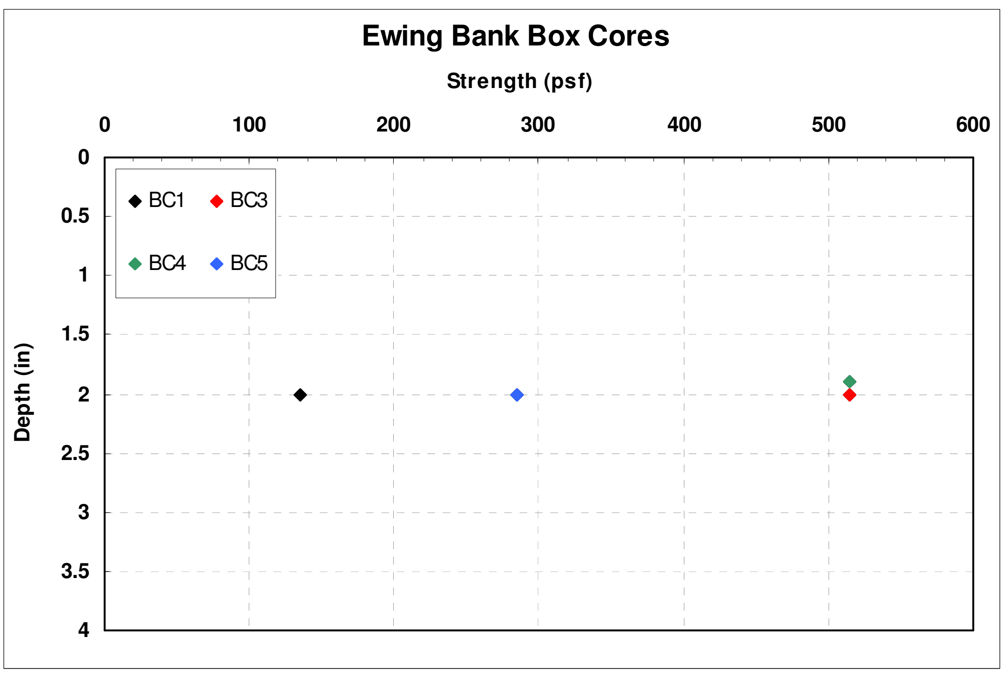


Figure 35: Box Core Miniature Vane Results Plot. Displayed in depth taken (y-axis) vs. their strength in psf (x-axis). There are only 4 of the 5 plotted as BC2 had significant sand which prevented using the Miniature Vane.

5.5 Methods – Multi Sensor Core Logger

The Multi Sensor Core Logger (MSCL) used for this project was manufactured by GEOTEK Limited and operated at TDI-Brooks International Facilities. The instrument is primarily used for measuring geophysical data in sediment cores that have been obtained from the ocean floor. The main sensor is an ultrasonic transducer that will measure the velocity of compressional waves in the core and a gamma ray source detector for measuring the attenuation of gamma rays through the core which allows the calculation of density and porosity.

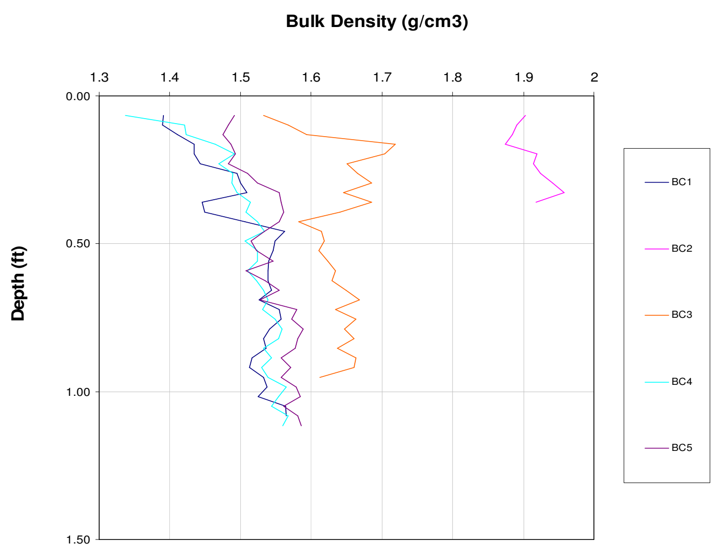
The gamma ray source, which is used for measuring geotechnical properties such as bulk density, porosity, void ratios, and water content, is mounted horizontally across the sediment core and a narrow beam of gamma rays is emitted. The photons then pass through the core and are detected on the other side. By measuring the number of unscattered gamma photons that pass through the core unattenuated, it is possible to calculate the density and porosity of the core (Boyce, 1976).

5.6 Results – Multi Sensor Core Logger

Bulk Density

Bulk Density is the mass of sediment particles and porewaters divided by the volume that they occupy. It is depends on the pore space, texture, and organic matter content of the sediment. The typical bulk density of sandy soil is approximately 1.6

g/cm^3 and the typical bulk density of clay soil is approximately 1.2 g/cm^3 (Best and Gunn,1999). The presence of organic material can increase these numbers up to 0.5 g/cm^3. The results from the MSCL analyses of the box core sediment samples provided insight into the type of material present and are presented below in Figure 29. The bulk density of BC1 ranges from 1.39 to 1.56 g/cm^3, which is very similar to that of BC3, BC4, and BC5 (all range around roughly 1.5 g/cm^3). In all of the box cores except BC2, the bulk density increases with depth and shows characteristics of clay as shown in Figure 36. BC2 has a higher bulk density, at an average of 1.9 g/cm^3, and shows characteristics more similar to sand.



BC1 BC2 BC3 BC4 BC5

Figure 36: Bulk Density Comparison. Box Cores (1, 2, 3, 4, 5) measured by MSCL at room temperature (70-ferenheight). It can be seen here that BC1,BC3,BC4,and BC5 all similar Bulk Densities while BC2 (which was primarily shell hash and sand) has a much higher Bulk Density closer to 2 (g/cm3).

Porosity

Porosity is a measure of the void space in a material and can be used to determine how well consolidated a sediment sample is. The average porosity for sand is approximately 40% and the average porosity for clay is approximately 55%. The results below show that BC1, BC3, BC4, and BC5 all have an average porosity of 70% and that this porosity decreases with depth in the core as shown in Figure 37. The average porosity for BC2 is 46% and is more indicative of sand. BC2's porosity also decreases with depth in the core.

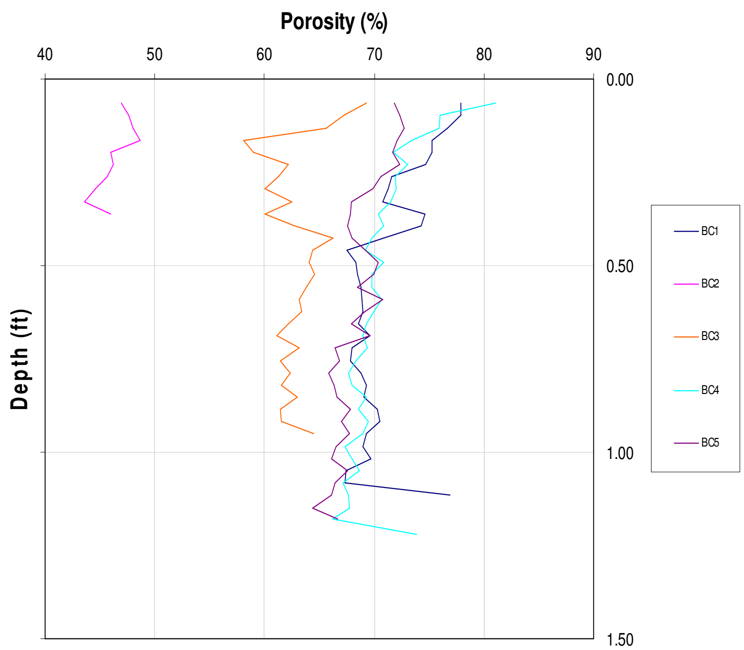


Figure 37: Porosity Comparison. Box Cores (1, 2, 3, 4, 5) measured by MSCL at room temperature (70-ferenheight). It can be seen here that BC1,BC3,BC4,and BC5 all similar Porosities of clays while BC2 (which was primarily shell hash and sand) has a much higher Porosity closer to .5 (%).

6. MULTIBEAM BATHYMETRY

6.1 Methods

The multibeam portion of this survey took place on the *RV Falkor* thanks to the Schmidt Ocean Institute. It set sail from Corpus Christi, Texas on November 26, 2012 with a crew of 14. It was in transit from Corpus Christi to Pascagoula, Mississippi and stopped by the Ewing Bank to collect data for Texas A&M University. It was on location from 10:30pm on November 27 to 1:30pm on November 28 and collected data at a speed on 12 knots on the western portion of the Ewing Bank using the ship's Kongsberg EM710 Multibeam Echosounder, which operates at the sonar frequencies in the 70 to 100 kHz range (see Survey Vessel section above). The data was processed by crew of the *RV Falkor* and E. Ramirez of Texas A&M University using CARIS software and provided to Texas A&M University personnel for further processing and scientific analysis.

Surveys for Multibeam Echo sounders consist of traveling across the desired survey area with the system on and providing the best coverage possible. The survey speed is selected and a route is followed to provide coverage over the entire proposed area. There is a degree of overlap that will occur in order to keep gaps from appearing in the data between survey lines. This overlap is determined by the survey crew and can range from 10% to 100% based upon the goals.

6.2 Results

The path of the *RV Falkor* is shown in Figure 38. In Figure 39 it is easy to distinguish the two terrace system of the Ewing Bank. The dark blue represents the deepest portion of the survey at approximately 200 meters depth and changes to light blue as the bank starts to rise at approximately 150 meters depth. There is then a very prominent yellow and green terrace that makes up the main portion of the bank at approximately 80-90 meters depth. Lastly there is the red to purple regions on Figure 38 that represent the highest portion of the bank. These red areas represent the top terrace system which is the shallowest in water depth and approximately 60-75 meters deep.

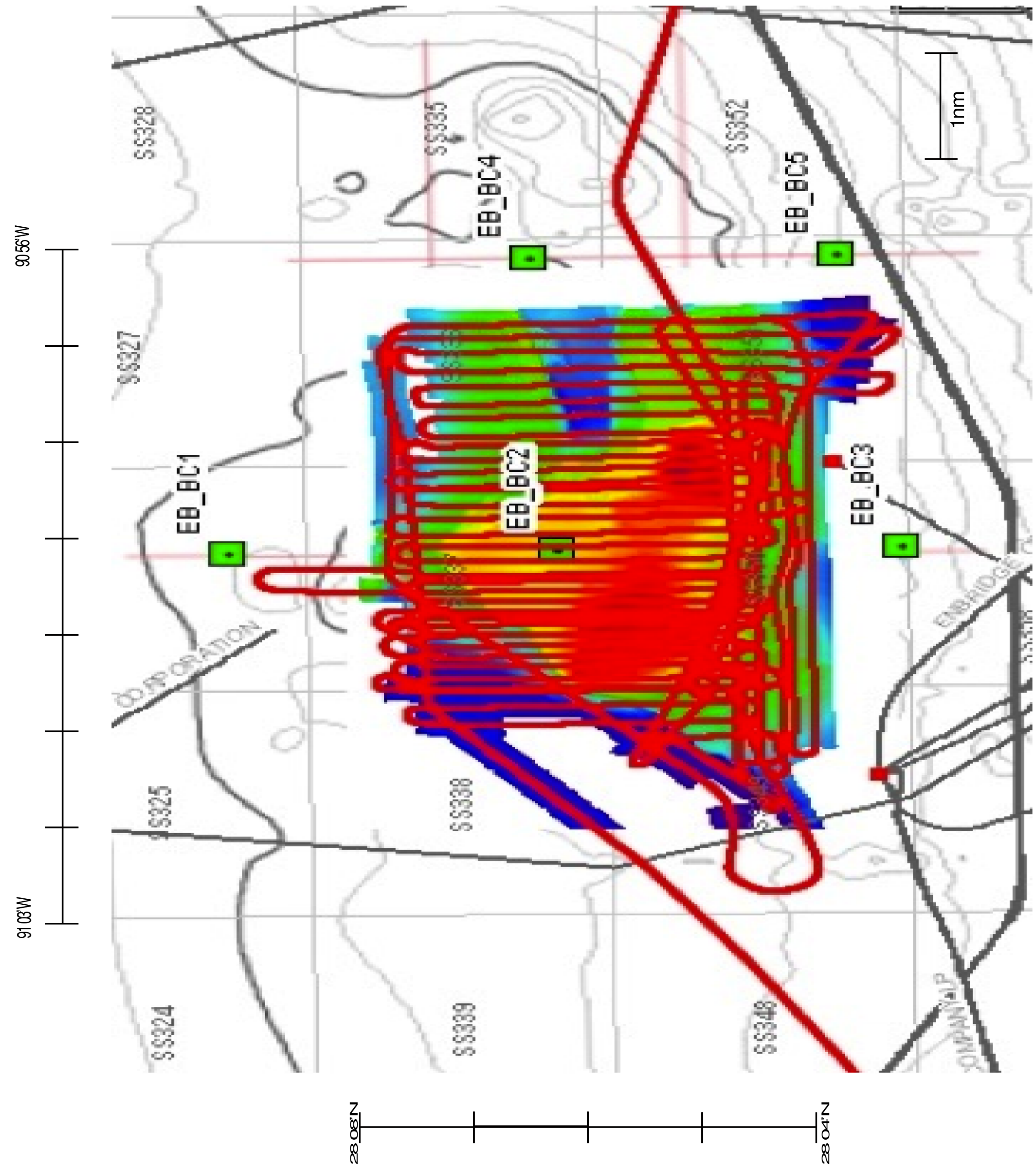


Figure 38: *RV Falkor* Survey Path for Multi-beam. Acquisition on the western portion of Ewing Bank.

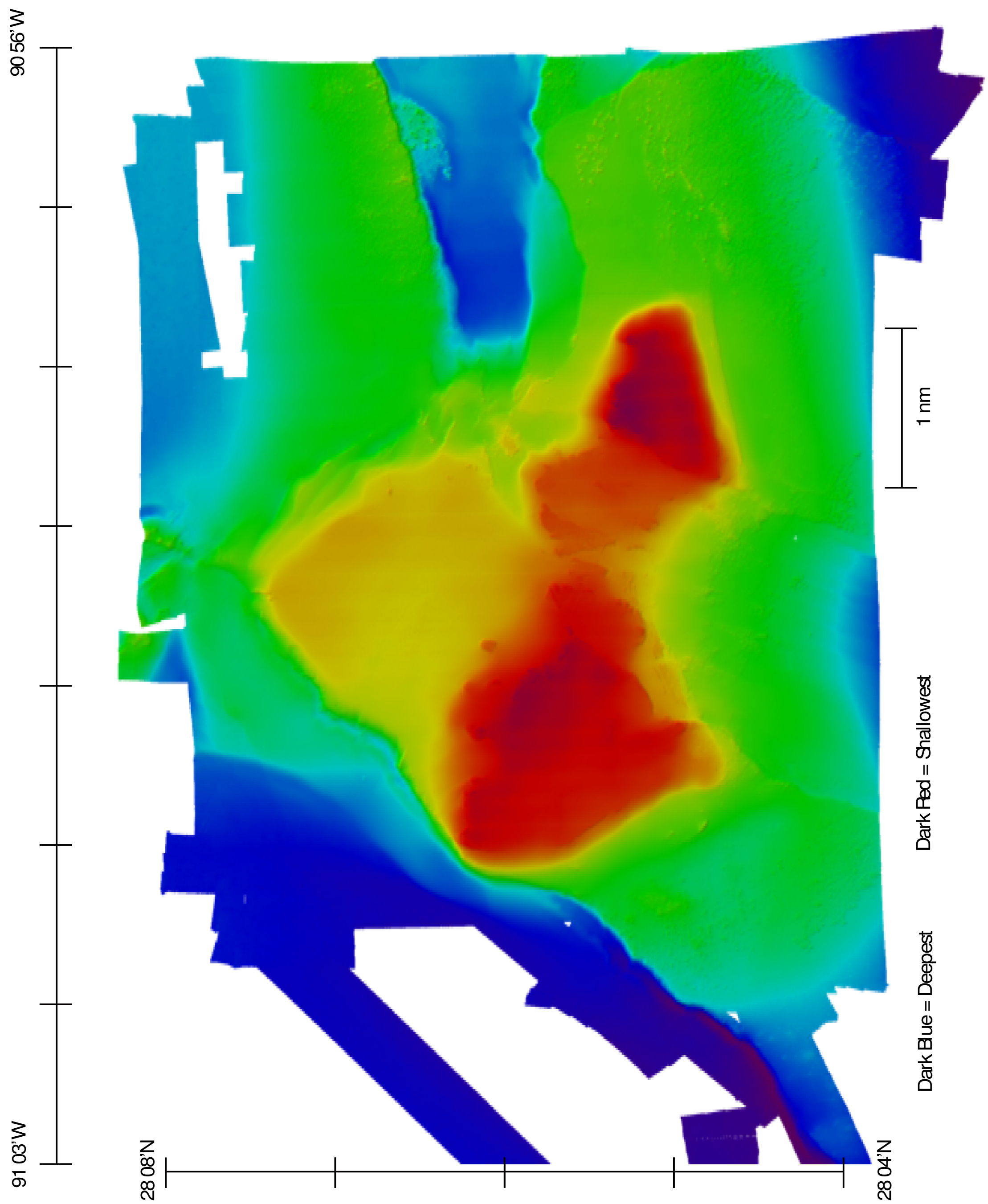


Figure 39: Multi-beam Image of the Ewing Bank. Showing the western portion of the Ewing Bank.

7. INTERPRETATION

7.1 Mapping the Bank - Terrace System

The sub-bottom profiler images show aspects of the sedimentary structures and types on the Ewing Bank. Sub-bottom profiler line, Figure 21, nicely shows that there is a two terrace layer to this bank. The seafloor reflections on these terraces are stronger and more prolonged than the seafloor reflection on the surrounding seafloor. This observation suggests that the terraces are likely covered by a harder sand layer while the surrounding seafloor is primarily softer clay. This occurrence of soft clays is consistent with the suggestion by Rezak et al. (1985) that much of the Ewing Bank might be covered by generally soft sediments, which are the terrigenous sediments transported to the area by the Mississippi River and shelf-edge currents. The presence of the strong seafloor reflector on the terraces and the occurrence of sand and shell hash in core BC2 indicates that currents and other local processes may have removed fine sediment from the terraces, leaving a concentration of coarser, biologically produced carbonate sands.

The multibeam echo sounder data confirms the presence of two primary terraces at the western portion of the Ewing Bank (see for example Figure 39). It shows clearly the top terrace in red at a depth of approximately 70 meters and the second, middle, terrace in yellow at a depth of approximately 90 meters, with the surrounding seafloor dropping down around the bank. The sub-bottom profiles and bathymetry show the middle of the top terrace collapsed at some point in time. This observation supports the suggestion by Rezak et al. (1985) that salt diapirism can cause a extension of the crest of a diaper and the subsequent collapse of the overlaying sediment (local dissolution of salt might contribute to this effect). Finally, the sub-bottom profiler images show there is significant tipping of the sedimentary layers up onto the edges of Ewing Bank, providing circumstantial evidence for the bank having been uplifted by salt diapirism. The shallower, younger sequence of sediment layers thins toward the bank's edges indicating these sediments were deposited after the uplift occurred.

7.2 Sediment Strengths

Inspection of the sediments in the box cores showed BC2 contained coarse, sandy shell hash while all of the other cores contained much finer grained sediments. The bulk density values measured by the MSCL is generally consistent with these observations, though the density values are slightly higher than would typically be expected of recently deposited sediments on the upper portion of the continental slope (especially core BC3). Shear strength may provide a clue as to why these differences exist.

A relative indicator of the strength of sediments at different locations about the Ewing Bank is provided by the depth of box corer penetration. Cores BC1, BC3, BC4, and BC5 similar recoveries in the range of 12” to 18”; however, core BC2 which was from the top terrace had only had 6” of penetration. This difference reflects the nature of the sediment: core BC2 contained sand and shell hash whereas all of the other cores contain clay. Directly measured shear strengths showed the natures of the sediments in cores BC3 and BC4 are not as similar to the others as expected based on core penetration/recovery. Their shear strengths were considerably higher than core BC1 and double the strength of BC5. The sub-bottom images show that the locations of BC3 and BC4 were located on tilted and uplifted sediments that are older and presumably more consolidated, which likely contributed to their increased strength. In contrast, core BC1 has the least strong sediments as might be expected given that it was not recovered from the bank itself, rather it was from the seafloor adjacent to the bank which appears to be draped by soft recently deposited sediment. When compared to the sediments in the other box cores, those in core BC5 display intermediate shear strength. Given the location of core BC5 just seaward of the edge of Ewing Bank, it is possible that its shear strength reflects an intermediate degree of consolidation or, when compared to core BC1, a greater silt-to-clay ratio due to winnowing by currents or other processes.

An interesting find is that core BC4 is composed of large amounts of clay and organic material. The initial expectation was that this core would contain coarser sediments like core BC2 because both cores were from the central, elevated region of the Ewing Bank. Inspection of the sub-bottom profile data indicates that core BC4 may have been recovered from a local depression, allowing for the accumulation of finer sediments.

7.3 Comparison and Processes

The Ewing Bank appears to be controlled by salt diapirism. This process is supported, in large, by the sub-bottom profiler images that were taken. These images show that an older sediment layer at the bank's edges was tilted, and uplifted, then covered with newer sediment layers that were recently deposited. These newer sediment layers are soft in composition, allowing good acoustic penetration and are thinning in direction of the bank. The uplift that has been observed in the sub-bottom profiler images shows faulting at the top of the bank such as the radial faults observed at other shelf-edge banks. Features like these are common to salt driven uplift that causes the bank to expand and subsequently crack and radially fault at the top. Part of the top terrace also appears to have collapsed, which supports the salt diapirism theory.

The Ewing Bank compares well with other banks in its region. When compared to nearby Diaphus Bank, which is located at 28.09 ° N and 90.71 ° W (see Figure 1), many similar features, can be found. Characteristics of the Diaphus Banks are presented by Bright and Rezak (1979) and Rezak et al. (1985). The Diaphus Bank ranges over the water depths from 70 meters to 130 meters, as does Ewing Bank. These banks both contain gentle north side slopes, steeper southern slopes, and are larger in the east to west direction than in the north to south. Both banks are found at the shelf edge, and they contain carbonate sand and shell hash on the top terraces and are flanked by soft clays on the sea floor. Finally, both banks show onlapping of younger sediments that were deposited on top of the older unit that was uplifted during the salt diapirism.

The Diaphus Bank is shown by seismic reflection to be a domal diapirc structure which supports the observations made at the Ewing bank that it is controlled by salt diapirism (Rezak et al., 1985).The comparison of the Ewing Bank with its neighbor Daiphus Bank suggests they have both been affected by salt diapirism.

8. SUMMARY AND CONCLUSIONS

There are several banks along the edge of the continental shelf of the northwestern Gulf of Mexico that are home to corals and other organisms (Rezak et al., 1985; Slowey et al., 2008). To better understand how these banks are functioning, it is necessary to understand their geologic processes and how they influence their environments. The Ewing Bank, which is located to the west of the Mississippi River delta, is a relatively large, important geologic feature. Yet, there is only limited historical bathymetric data from the bank and surprisingly few other details are known about its surficial geologic features. The research presented here represents a preliminary survey of the distribution and structure of the seafloor sediments that comprise the bank based on the combined results obtained from sub-bottom profiles, geologic cores, and multibeam echo sounder bathymetry.

The new sub-bottom profiles, sediment core samples, and bathymetric data from Ewing Bank show several basic features. The bank is a topographic high that rises from the surrounding seafloor (about 150-200 meters deep) to within approximately 60 meters below the sea surface. Several terraces exist on the bank, including a shallow terrace at about 60 meters depth and a deeper terrace at approximately 80-90 meters below the sea surface. Sediment beds along the bank edge are generally tilted up towards the center of the bank, and there are two sets of sediment layers: an older sediment layer that is uplifted and newer sediment layers being deposited on after. Faults occur in the central region of the bank and a collapse feature is present. While sediments on the seafloor surrounding the bank are soft and fine grained, the sediments on the surface of the bank's edge and bank's terraces are stiffer clay and sandy shell hash.

All of these geological aspects of the Ewing Bank suggest salt diapirism played a big role in the formation of this bank. The upward motion of the salt pushed up the sediments on the shelf edge to cause the tilting and faulting, as well as the collapse feature and the exposure of older, stiffer sediments at the seafloor. The results presented in this study provide new insight into the nature of Ewing Bank and indicate its origin is similar to that of many other banks along the edge of the continental shelf of the northwestern Gulf of Mexico.

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